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REPORT NO. UMTA-MA-06-0100-81-3

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MANAGEMENT OF URBAN CONSTRUCTION PROGRAMS
Volume II: Supplemental Information

National Research Council
Commission on Sociotechnical Systems
Building Research Advisory Board
Committee on Management of Urban
Construction Programs
2101 Constitution Avenue, N.W.
Washington DC 20418

JUNE 1981
FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
Office of Technology Development and Deployment
Office of Rail and Construction Technology
Washington DC 20590

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16. Abstract

This report of the BRAB Committee on Management of Urban Construction Programs is intended to guide local authorities (such as transportation, water, and sanitary agencies) in developing management plans for executing urban construction projects. BRAB developed the report setting forth the Committee's guidance concerning:

a. Developing project management for planning and executing urban construction projects;
b. Assigning responsibility, authority and control in the decision-making process;
c. Developing the communication mechanisms and documentation required for implementation of management and construction; and
d. Identifying procedures for initiating and developing management plans for urban construction projects.

Using information gathered and the knowledge and expertise of its members, the Committee prepared a two volume report. In Volume II supplementary information compiled by the Committee is presented from material it reviewed and developed during the course of its study. It includes information on conceptual planning and examples of techniques and procedures that have been used which might be helpful to project managers in understanding the management process and in developing and executing project management plans. The information presented is not intended to be all-inclusive and is offered without recommendation of any specific approach.

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16. Abstract

This report is part of a program sponsored by the Office of Rail and Construction Technology of the Urban Mass Transportation Administration. The overall objective of the study is to develop guidelines that can be used by local government authorities, such as transportation, water, and sanitation agencies, in developing sound management plans for the execution of Federally-funded urban construction projects. This report presents the guidelines from the perspective of the Project Manager, since this position carries the responsibilities for design and construction of a particular project, and possibly, for activation and operation of a facility or system. The Building Research Advisory Board (BRAM) Committee developed this study outlining these concerns: 1) developing project management for planning and executing urban construction projects; 2) assigning responsibility, authority, and control in the decision-making process; 3) developing the communication mechanisms and documentation required for implementation of management and construction; and 4) identifying procedures for initiating and developing management plans for urban construction projects. Using information gathered and the knowledge and expertise of its members, the Committee prepared this two-volume report. In this report, Volume II, supplementary information compiled by the Committee is presented from material reviewed and developed during the course of its study. It includes information on conceptual planning and examples of techniques and procedures that have been used which might be helpful to Project Managers in understanding the management process and in developing and executing project management plans. The information is not intended to be all-inclusive, and is offered without recommendation of any specific approach.

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PREFACE

This report was prepared by the Building Research Advisory Board (BRAB) Committee on Management of Urban Construction Programs under Contract No. DOT/TSC-1728 managed by the Transportation Systems Center (TSC), Cambridge Massachusetts. The contract is part of a program sponsored by the Office of Rail and Construction Technology, Office of Technology Development and Deployment, Urban Mass Transportation Administration (UMTA) of the U.S. Department of Transportation.

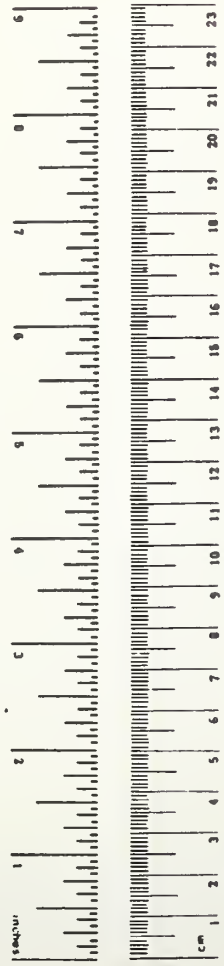
The overall objective of this contract is to develop guidelines that can be used by local governmental authorities in developing sound management plans for the execution of federally funded urban construction projects. The report presents the guidelines from the perspective of the project manager since this position carries the responsibilities for design and construction of a project and, possibly, for activation and operation of a facility or system.

The guidance and suggestions of Mr. Paul Witkiewicz of the Transportation Systems Center, technical monitor, and of Mr. Gilbert Butler of the Urban Mass Transportation Administration, program manager during the study effort, were greatly appreciated.

METRIC CONVERSION FACTORS

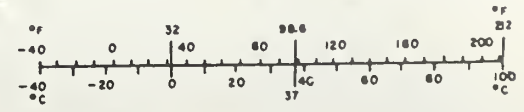
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.5	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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FOREWORD

The management of large-scale public works projects is an increasingly important issue. The major investment of public funds in such projects requires a comprehensive management plan that covers all aspects of a project from initial conception, through the political, financial, design and construction stages, and into actual operation. It is, however, particularly difficult for local governments to assemble the management and engineering capability needed to handle such projects. The work of the BRAB Committee on Management of Urban Construction Programs is specifically oriented toward providing these local entities with a guide that will help them carry out this important and complex function.

Joseph H. Zettel, Chairman
Building Research Advisory Board

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I
INTRODUCTION

The increasingly critical situation arising from failure to deal effectively with inherent risks in construction prompted the Building Research Advisory Board (BRAB), with the support of the U.S. Department of Transportation, to conduct an exploratory study on responsibility, liability, and accountability for risks in construction. Of principal concern, particularly on large-scale public works projects, were rapidly escalating costs and delays or actual denial of vital public services. A series of workshops, one of which was devoted to urban and suburban mass transit construction, and a conference were held to identify problems and practical solutions.

The BRAB Committee responsible for this exploratory study identified the administration and management of the construction process as an area in which major problems arise concerning responsibility, liability, and accountability for risks. In its final report (Exploratory Study on Responsibility, Liability, and Accountability for Risks in Construction, 1978), the committee concluded:

> Delays that cannot be known or predicted adequately result in the greatest losses to all parties to the construction process but most particularly to the owner and the general public. Even predictable delays have a serious impact on the sequencing and efficiency of project execution.
>
> A lack of understanding of authority and responsibility and a lack of coordination and communication generally exist among the parties to the construction process. These differences together with an adversarial relationship that often exists among the parties cause ambiguity or inequity in allocation of liability and increase the likelihood of costs in disputes. Delay and losses due to cost escalation and reduced productivity and beneficial use of a facility also may result.

The Committee recommended that:

> Decision-making roles at all levels in the construction process should be identified and defined and the requisite responsibility and authority should be assigned in order to improve the badly disjointed decision-making process that now exists.... Mechanisms that will provide better communication and development of the team approach among all parties to the process should be explored in order to further minimize escalating adversary relationships.

The increasing size and complexity of many public service projects and the involvement of federal, state, and local governmental grant and regulatory agencies complicate management of the delivery process. Recently developed methods of designing and constructing major urban construction projects and the actions of governmental and nongovernmental public groups have further complicated management of the process.

Sound management practices, communicated to all participants in the construction process, are essential if the concurrent activities in the process are to be controlled, performance is to be evaluated and measured, and corresponding benefits in time and cost are to be achieved. However, every major construction project is unique, occurring in a specific locale with specific people participating in the process, and no one management plan can be used by all agencies or in all situations. Nevertheless, the primary elements necessary to sound management plans can be identified.

Stimulated by the conclusions and recommendations reached in the BRAB exploratory study, the U.S. Department of Transportation's Urban Mass Transportation Administration requested that BRAB undertake a study of management of urban construction programs to develop guidance that could be used by local governmental authorities in developing sound management plans for the execution of federally funded urban construction projects. The results of this study are the subject of the report.

A. PURPOSE AND SCOPE OF REPORT

This report of the BRAB Committee on Management of Urban Construction Programs is intended to guide local authorities (such as transportation, public works, and sanitary agencies) in developing management plans for executing urban construction projects.

The guidance presented has been developed from the point of view of the "project manager." Because of the unique aspects of every major construction project, it is not possible to define exactly the function and the full responsibility and authority vested in

the project manager position; however, it is assumed that the position carries responsibility for design and construction of a project and, possibly, for activation and operation of a facility or system. The conceptual planning phase of a project, during which needs, conceptual contentions, social and environmental impacts, and local political acceptance are evaluated, is not covered in detail since the results of this phase are taken as givens for the project management plan.

B. CONDUCT OF THE STUDY

The BRAB Committee on Management of Urban Construction Programs was charged with developing a detailed plan for and implementation of study activities and to prepare a report setting forth the Committee's guidance concerning:

a. Developing project management plans for executing urban construction projects;
b. Assigning responsibility, authority, and control in the decision-making process;
c. Developing the communication mechanisms and documentation required for implementation of management of construction; and
d. Procedures for initiating and developing management plans for urban construction projects.

The Committee conducted an informal survey to review management guidelines and procedures for executing construction projects that have been developed by both public and private organizations. Included in this survey were 17 local transportation authorities that were asked whether they had a formal management plan for executing urban construction projects. If they did, they were asked to sub- mit a copy and explain when it was instituted and how staff members and other project participants were familiarized with it. If they did not have a formal plan, they were asked to submit copies of memos, reports, or other documents used to execute construction projects. In addition, they were asked to submit an organization chart, if available, that would show the organizational structure and staffing of the authority, how construction activity related to the overall structure, and how responsibility and authority were delegated among the various personnel. A summary of the Committee's findings and conclusions regarding the survey appears in the appendix to Volume 1 of the Committee's report.

Using the information gathered and the knowledge and expertise of its members, the Committee prepared this two-volume report. In Volume 1, the Committee sets forth its conclusions and recommendations regarding the purpose of a management plan, the major elements of a management plan, possible alternatives for essential elements, and guidance for selecting among the alternatives for each element. The Committee has made a particular effort to present the guidance in Volume 1 as concisely as possible without

giving detailed procedures or standards for executing a plan. The results of the Committee's survey of local transportation authorities are presented in an appendix. In this document, Volume 2, the Committee presents supplementary information compiled by the Committee from material it reviewed and developed during the course of its study. It includes information on conceptual planning and examples of techniques and procedures that have been used that the Committee felt might be helpful to project managers in understanding the management process and in developing and executing project management plans. The information presented is not intended to be all-inclusive and is offered without recommendation of any specific approach.

II
SUPPLEMENTAL INFORMATION ON THE CONTENTS OF A MANAGEMENT PLAN FOR URBAN CONSTRUCTION

A. PARAMETERS AND CONSTRAINTS

As noted earlier, the guidance presented in Volume 1 of the Committee's report does not cover the conceptual planning phase of a project; however, the Committee recognizes the importance of this phase and its interface with the project management phase. The following excerpt from Better Management of Major Underground Construction Projects (1978) by the National Research Council's U.S. National Committee on Tunneling Technology is offered to strengthen the reader's understanding of the interface between the conceptual planning and project management phases.

PROJECT PHASING

Each major project, public or private, starts with the recognition of a need. The process of conceptual planning identifies the facility required to best meet the need. The conceptual plan describes the facility in general terms and, in the light of available information, compares the balance of economic, social, and other benefits against the estimated costs and any perceived adverse impacts. A favorable balance of factors should lead to a recommendation to go ahead and could help establish a mandate for the project. The agency or organization that would be responsible for executing the plan should also be identified or recommended in the conceptual planning phase.

The steps leading to completion and operation of the project are:

- Project Organization
- Project Planning, including review and possible revision of the conceptual plan; preliminary engineering. (The project organization and planning phases can be, and often are, combined.)
- Project Execution
  - Initial Phase
  - Preliminary Design Phase
  - Final Design Phase
  - Construction Phase
  - Start-up and Operations Phase

The boundaries between the conceptual planning, project planning, preliminary design, and final design phases are not fixed precisely and may not be recognized as separate phases in the execution of all projects. Conceptual planning and project planning phases may be combined, eliminating a "go or no-go" decision between these two functional phases. This is more common in major private projects than in public projects. The project planning phase may include functions frequently carried on in the preliminary design phase or may lose its identity as a phase if combined with the conceptual planning phase. Preliminary design may be combined with final design. This also is more common in major private projects than in public projects. Within most

major public projects, sequencing of the work, as it relates to major geographic segments, will result in different segments proceeding through different development phases at any one period. However these phases are divided, the sequence described here is a fundamental requirement to well-ordered project development and execution.

It is highly unlikely that any two major projects have followed the same course or sequence of phases with the same functions assigned to each. During each discrete phase the actions by financing agencies, political entities, other involved agencies, the public, owners, designers, and contractors influence and possibly affect the progress of the project.

Because each large project is different from those that preceded it and those that will follow, it is impractical to select a particular historical example to illustrate the phasing of a major underground construction project. A model was developed to illustrate the variety of factors likely to be involved. Figure 1 shows the general sequence of project phases, from conceptual planning to start-up and operations, the major activities that take place in each phase, and the characteristic flow from one phase to the next. The bottom lines of Figure 1 display those activities that continue throughout the project, from the inception of conceptual planning through the start-up of operations.

CONCEPTUAL PLANNING

The conceptual plan is an overall master plan of the project developed primarily by the application of professional planning disciplines supported by engineering and architectural disciplines. In the case of a rapid transit project the conceptual plan would generally identify the facilities to be built, the desired operating systems, the service areas and corridors, the supplemental support elements, such as feeder lines, and the manner in which the project operation would be integrated with other transportation modes and systems in the area, those both existing and planned. Of necessity, the plan would include an assessment of needs, maximization of favorable social, economic, environmental and aesthetic impacts, minimization of unfavorable consequences, and both initial and continuing costs. Important factors that need to be considered in the plan are public and political support, approximate costs, economic feasibility, financing alternatives, ridership estimates, the direction and character of community growth, physical conditions, institutional influences, and other factors of general or local significance. The conceptual plan provides a general description of facilities and systems that are calculated to best meet the needs of the community and presents a favorable balance of impacts. The conceptual plan also [may recommend] the type of agency or specify the existing agency to be charged with the responsibility of carrying out the project under a defined mandate.

The starting point for this project management study is after the completion, acceptance, and approval of the conceptual plan and the establishment of an authority responsible for the implementation and control of the project. While project management during the conceptual planning phase is not part of this study, it is patently clear that the quality of management during this phase as well as the quality of the conceptual plan will have critical bearing on the project in all subsequent phases. Concepts that are not realistic at the outset require revisions that could cause delays and modifications of the project.

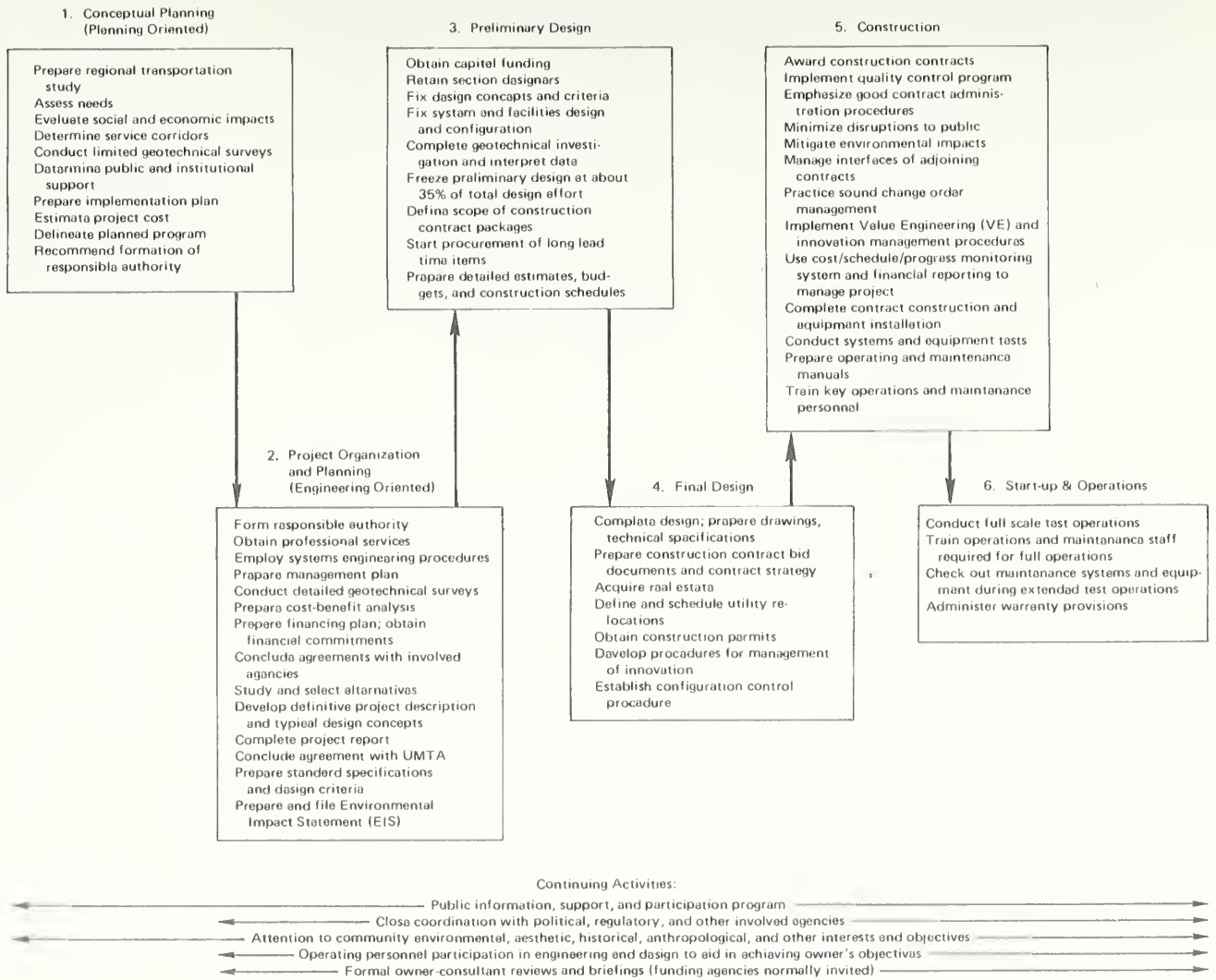

1. Conceptual Planning (Planning Oriented)
Prepare regional transportation study
Assess needs
Evaluate social and economic impacts
Determine service corridors
Conduct limited geotechnical surveys
Determine public and institutional support
Prepare implementation plan
Estimate project cost
Delineate planned program
Recommend formation of responsible authority
2. Project Organization and Planning (Engineering Oriented)
Form responsible authority
Obtain professional services
Employ systems engineering procedures
Prepare management plan
Conduct detailed geotechnical surveys
Prepare cost-benefit analysis
Prepare financing plan; obtain financial commitments
Conclude agreements with involved agencies
Study and select alternatives
Develop definitive project description and typical design concepts
Complete project report
Conclude agreement with UMTA
Prepare standard specifications and design criteria
Prepare and file Environmental Impact Statement (EIS)
3. Preliminary Design
Obtain capital funding
Retain section designers
Fix design concepts and criteria
Fix system and facilities design and configuration
Complete geotechnical investigation and interpret data
Freeze preliminary design at about 35% of total design effort
Define scope of construction contract packages
Start procurement of long lead time items
Prepare detailed estimates, budgets, and construction schedules
4. Final Design
Complete design; prepare drawings, technical specifications
Prepare construction contract bid documents and contract strategy
Acquire real estate
Define and schedule utility relocations
Obtain construction permits
Develop procedures for management of innovation
Establish configuration control procedure
5. Construction
Award construction contracts
Implement quality control program
Emphasize good contract administration procedures
Minimize disruptions to public
Mitigate environmental impacts
Manage interfaces of adjoining contracts
Practice sound change order management
Implement Value Engineering (VE) and innovation management procedures
Use cost/schedule/progress monitoring system and financial reporting to manage project
Complete contract construction and equipment installation
Conduct systems and equipment tests
Prepare operating and maintenance manuals
Train key operations and maintenance personnel
6. Start-up & Operations
Conduct full scale test operations
Train operations and maintenance staff required for full operations
Check out maintenance systems and equipment during extended test operations
Administer warranty provisions
Continuing Activities:
Public information, support, and participation program
Close coordination with political, regulatory, and other involved agencies
Attention to community environmental, aesthetic, historical, anthropological, and other interests and objectives
Operating personnel participation in engineering and design to aid in achieving owner's objectives
Formal owner-consultant reviews and briefings (funding agencies normally invited)

FIGURE 1. TYPICAL PROJECT PHASES (MAJOR FUNCTIONS)

B. ORGANIZATION AND STAFFING

The following excerpt from the report of the U.S. National Committee on Tunneling Technology cited above provides information on organizational alternatives.

ORGANIZATIONAL ALTERNATIVES

There are several alternative ways of organizing a major underground construction project, and success can be achieved by more than one organizational model. There are four salient factors which, when considered together, will assist the owner in establishing the best organizational arrangement for a particular project. The first of these is the objective (or objectives) of the owner in undertaking the project. The second is the present or projected management capability of the owner. The third is the set of laws and regulations governing the owner's actions. The fourth factor is the resources, including the funds, of course, that are available to accomplish the entire project. The owner should strive to organize the project for the maximum efficiency possible, taking all four factors into account. If the factors are carefully considered, the advantages and disadvantages of each organizational arrangement will be apparent, and the best can be selected.

The organization necessary to construct a major project can be described as the organization of organizations--or the management structure--necessary to complete the project. An example of the owner's organization and possible organization charts for three different arrangements for overall project management are shown in Figures 2-5.

ORGANIZATIONAL OBJECTIVES

The basic objective in organizing the management of a major underground construction project is to successfully complete the project. To accomplish this basic objective, there are several important specific actions the owner must take. These are:

- Designate specific responsibilities, coupled with commensurate authority.
- Assign to specific organizations functions necessary to manage the project. Dual assignment of functions must be avoided.
- Establish clearly defined and understood channels of communication.
- Set the legal requirements governing the actions of the owner and the other organizations in the project management team. Once established, these must be adhered to.
- Staff the organizations with qualified individuals in the proper numbers to accomplish the assigned missions. At the same time, overstaffing must be avoided.
- Develop an objective means for the owner to review major decisions recommended by the project management team.
- Assemble an organization that is flexible and capable enough to come to grips with changes in emphasis as the project proceeds.

ORGANIZATION OF THE OWNER'S STAFF

The owner or authority is the organization with the overall responsibility for construction of the project. In a major underground construction project, the owner often is a public body, although a commercial firm can act as the owner in constructing projects for its own use. In this discussion, emphasis is on the public owner, but the principles and practices described may be readily adopted for use by a business firm.

Some agencies involved with underground construction have clearly defined and continuing missions, specific financing arrangements, and authority to administer the work effectively. In contrast, other agencies may be formed for a specific project. They begin with a general scheme that, once implemented, will have good and bad impacts on various elements of the community. In addition, the federal government usually provides a large part of the finance, but only after a preliminary plan has been developed and a political entity has been formed to carry out the plan. For such an agency to produce an effective operating system at a reasonable cost, it must clearly define its organization and the duties and responsibilities of its board and staff. This must be

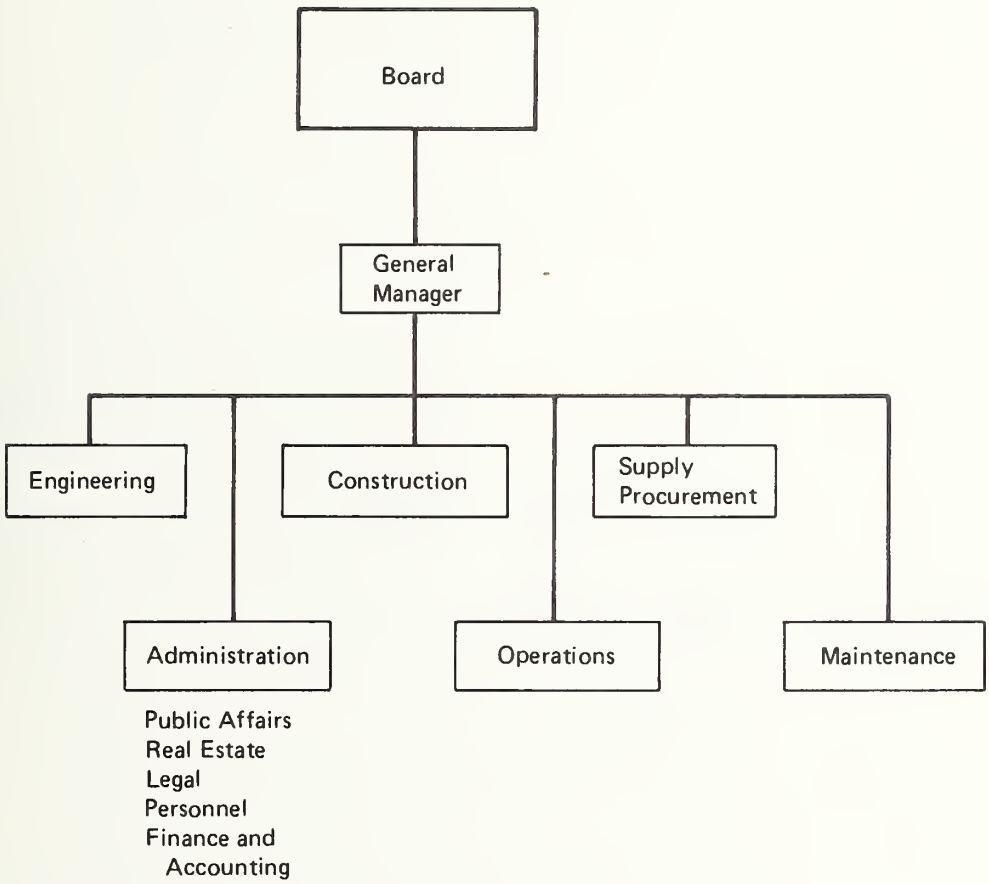


FIGURE 2. TYPICAL OWNER ORGANIZATION

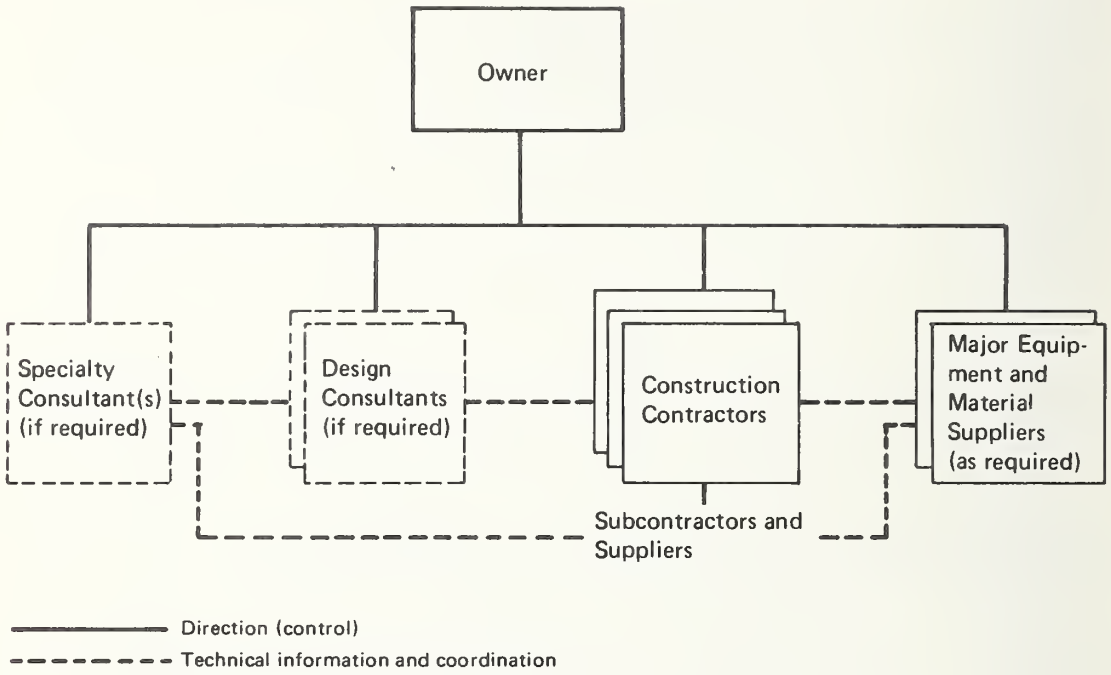
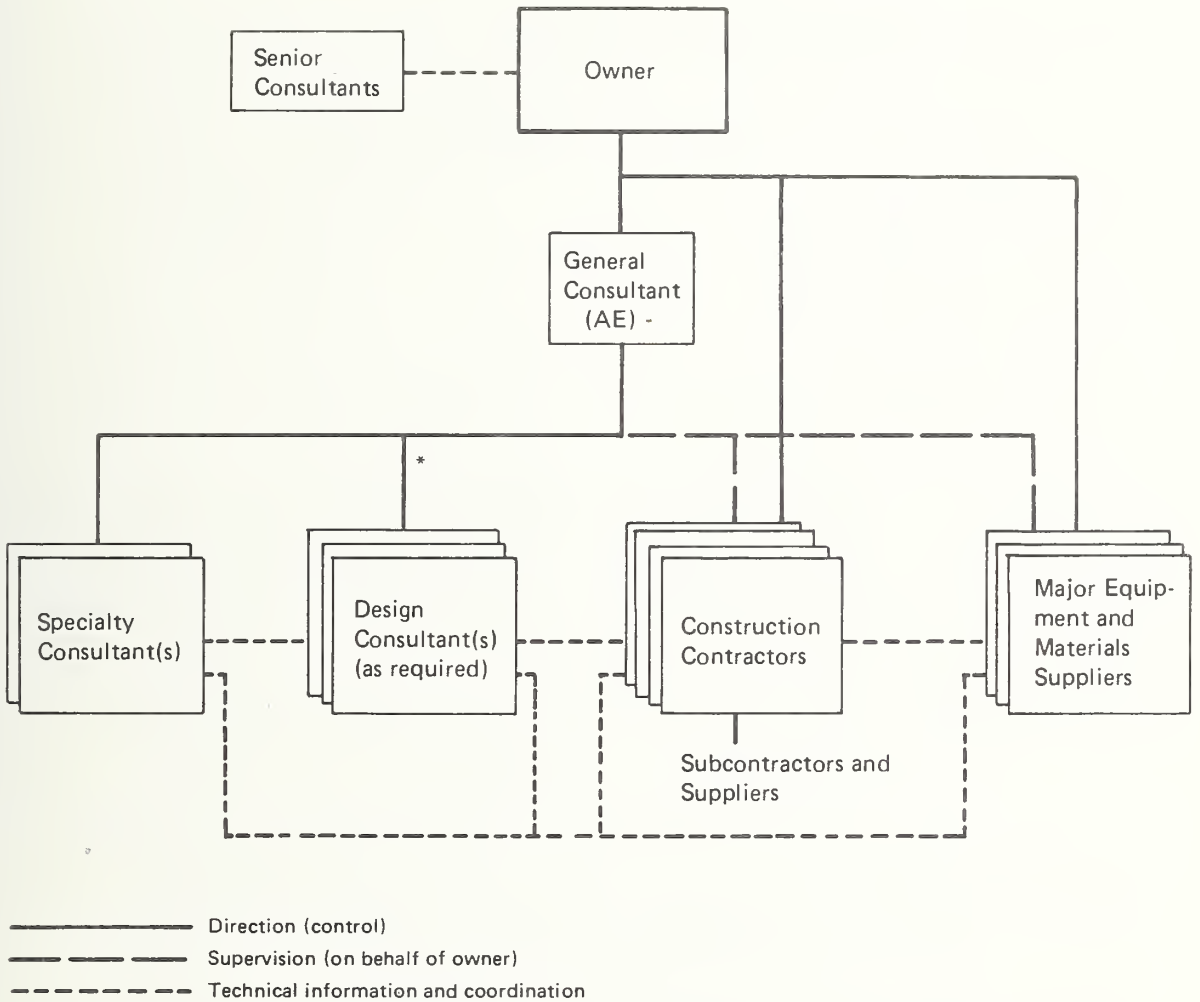
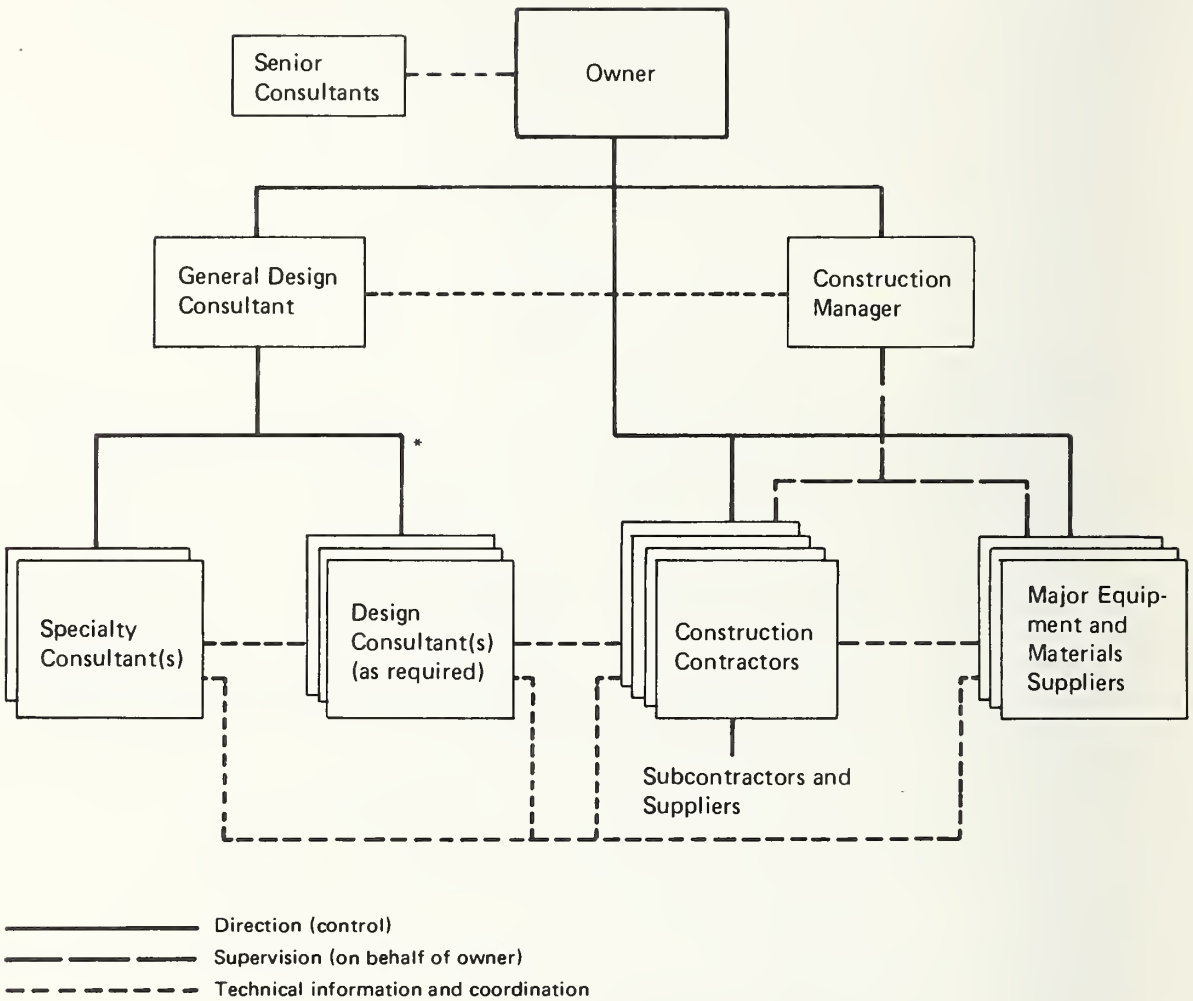


FIGURE 3. PROJECT ORGANIZATION—ESTABLISHED OWNER MANAGES DESIGN AND CONSTRUCTION DIRECTLY



*This diagram shows design consultants as subcontractors to the general consultant. An alternative can be technical supervision of design consultants by the general consultant on behalf of the owner, to whom design consultants are under contract.

FIGURE 4. PROJECT ORGANIZATION—GENERAL CONSULTANT MANAGES DESIGN AND CONSTRUCTION FOR OWNER



*This diagram shows design consultants as subcontractors to the general design consultant. An alternative can be supervision of design consultants by general design consultant on behalf of owner, to whom design consultants are under contract.

FIGURE 5. PROJECT ORGANIZATION—GENERAL DESIGN CONSULTANT MANAGES DESIGN AND CONSTRUCTION MANAGEMENT CONSULTANT MANAGES CONSTRUCTION

done early, with careful attention to detail in drafting the enabling legislation, taking advantage of the knowledge gained from earlier successes and failures. Later, grantors of financial assistance will need to review the legislation as well as the actual organizational structure and operating procedures of the agency, in order to determine that all these elements will effectively produce a successful project.

Owner

The owner, whose charter is usually prescribed by the state legislature, consists of the governing board or commissioners who may be elected or appointed. Among the more important functions performed by the board in executing its responsibilities are:

- o Establishing policy
- o Assuring financing of the project
- o Approving budgets and expenditures
- o Approving contract documents
- o Approving award of contracts
- o Acquiring land
- o Executing the project

The board is assisted in its functions by the general manager or executive director whose responsibility is the day-to-day operation of the authority. He is assisted by heads of such departments or individuals as engineering, construction, real estate, finance and accounting, procurement, legal, personnel, operations, and public affairs. Figure 8 illustrates a typical owner organization.

The size and capabilities of the owner's staff will be influenced or determined in part at least by answers to the following questions:

- o Is it a new organization or an existing one? What are its present capabilities?
- o Will it be responsible for future construction projects or only the current one?
- o How long is the project expected to take to complete?
- o Will it become primarily an operating organization after completion of the present project?
- o To what extent are qualified consultants available to provide technical and managerial services?
- o Will a general consultant be engaged to perform or supervise the planning, engineering, and construction, or will these functions be performed by separate consultants or by the authority?

At this point, the owner must make a major decision with respect to alternative approaches, generally as follows:

A. To delegate responsibility to a general consultant for planning, designing, constructing, building, and equipping the facility or to delegate the management of design and construction to separate consultants.
B. To develop an in-house staff to undertake the whole project.
C. To develop an organization that takes advantage of the benefits of both A and B. All three approaches have been used with varying degrees of success.

In making the decision, a major factor to be considered by the owner is that a knowledgeable staff is required to assure the owner of efficient and economical operation when the project is completed and to ensure that the lessons learned from operating and maintaining the project are fed back into the design process.

There are successful examples of owners performing the overall management function with a very small staff, relying on a general consultant for the detailed work necessary. On the other hand, there are successful owners with sufficient staff to do the planning and most of the engineering design and construction supervision. Moreover, there are examples of a combination of these two approaches. By careful consideration of the alternatives, it is possible to make a rational decision concerning the amount of detailed involvement in project management by the owner's staff.

Whatever the organizational pattern, it is imperative that the owner make certain that the necessary mechanisms exist to permit prompt and final decision-making on all significant questions and that the various elements work together as a team.

ORGANIZATION FOR DESIGN (PRELIMINARY AND FINAL)

Three basic alternative means of organization for preliminary and final design exist:

- o The owner's staff may do all design work. This alternative is usually appropriate when the authority is established and possesses considerable design experience and well qualified staff. A major underground construction project is often too large and complex for such an arrangement. In some instances, therefore, the owner's staff may supervise and manage the design by engineering firms retained to design sections of the project.
- o A general consultant may be engaged to perform all design work if the project is not too large for one firm and if the time available for design is adequate. If a general consultant is engaged, the proper basis of selection is proven successful experience in similar work by that firm and a commitment to assign a manager and staff qualified to do the job.
- o The third alternative is essentially a variation of the second. It entails the design of specific sections of the work by other engineering design firms and the overall management and coordination by the general consultant.

In the latter two alternatives the general consultant will perform the preliminary design of the entire system and prepare a preliminary construction schedule and estimates. After the preliminary design, schedule, and estimates have been approved by the authority, the general consultant will proceed with the detailed design of the system, consisting of a number of sections. These individual sections may be assigned to other engineering firms, which may be subcontractors to the general consultant or to the owner, with technical supervision provided by the general consultant.

Continuity in engineering services is essential and either the owner's staff or a consultant retained for that purpose should be available from the preliminary phase through final design and construction. An essential part of this role is the preparation and updating of schedules and estimates. When approved by the owner, these will be used as a basis for supervising the design and construction. Designers and design managers will provide design services during construction.

C. MANAGEMENT CONTROL SYSTEMS

1. Functional and Technical Control

a. Design Review

The following information defines the content of the various review submittals made during the design process for a rapid transit project. It applies principally to facilities design and is intended to guide the designer and to serve as a realistic basis for evaluation of submittals. It is assumed that design schedules always will be of the minimum necessary duration regardless of phase; that line design will be carried forward to the preliminary level and that station design will be carried forward to the conceptual level; that failure to meet the requirements given will be cause for rejection of the submittal and will necessitate resubmittal when the necessary requirements have been met; and that, at each submittal level, comments on the previous submittal will have been addressed and incorporated or resolution coordinated.

(1) In-Progress Preliminary Submittal

This submittal is intended primarily to allow an organizational review of the recommended alignment, including evaluation of the rejected alternatives. As such, all the factors affecting the recommendation must be addressed in the plans and/or design report.

Maximum allowable design speed throughout the alignment must be shown. Crossings of major drainage ways, including flood plain elevations, gross area of drainage basin, etc., must be shown. Major utility conflicts (i.e., any conflict influencing line location or having cost and/or schedule impact) must be identified. Parties affected, including utility owners, railroads, government agencies and private owners, should be listed. Deviations from the conceptual plans should be justified. Attempts to ameliorate impacts discussed in the environmental impact statement (EIS) must be stated. Physical constraints on the alignment should be identified. Economic comparison of discarded alternatives should be made.

(2) Preliminary Submittal

This submittal marks the dividing line between preliminary and detailed design. As such, it must:

- Define the impact of construction on all affected parties including utilities, railroads, governmental agencies, commercial properties, and residential areas.
- Serve as a permanent record of design development and reflect the basic concurrence of all parties.
- Define the scope of work for detailed design of the line and related facilities.
- Provide a feasible, but not necessarily optimum, solution for every major conflict.
- Provide a satisfactory basis for a realistic estimate of the cost of construction, which will serve as a budget.
- Establish the system "footprint" or permanent shadow with respect to right-of-way.

Separate requirements should be established for the submittals of the various disciplines (e.g., civil, structural, electrical, mechanical, and architectural design).

The design report is part of the documentation of preliminary design. It should address and record the justification for, and analysis of, design requirements. An estimate of the cost of construction also must be prepared and submitted.

(3) In-Progress Submittal

This submittal primarily is intended to provide a clear indication of progress toward detailed design solutions for problems outlined in earlier submittals. In addition, it provides a vehicle for the detailed coordination of requirements by others. Areas to be considered are civil design, right-of-way, structural design, and mechanical and electrical design.

Resubmittal of the design report is not required at the in-progress level. Deviations from the preliminary design report and the justification for such deviations should be addressed in the transmittal letter for the submittal. An indexed set of all the projected calculations also should be submitted.

With respect to the specifications, this submittal is intended to provide the complete framework for development of the contract documents. Format and layout of the specifications should be coordinated prior to submittal and the bid items list should be developed with the exception of minor items to be added later. Specifications for troublesome items such as railroad work, concrete, earthwork, and signalization should be developed in depth.

(4) Prefinal Submittal

This submittal is intended to provide the owner, his principal design consultants, and all agencies with the opportunity to review the proposed construction; to serve as a basis for obtaining concurrence from city, county, state, federal, private utility, and railroad officials; and to provide a basis for an estimate of construction cost.

The design, including all disciplines, should be complete and essentially checked. The plans must show all details necessary for construction and must be coordinated among the various disciplines prior to submittal. Detailed checking by the designer may proceed during the prefinal review period.

During the interval between in-progress and prefinal submittals, the following must be done:

- Resolution of all previous comments with solutions incorporated in the plans and specifications.
- Concurrence obtained at the technical level with solutions developed for individual conflicts.
- Drawings of the contract plans that involve rearrangements of city-owned facilities completely checked, signed, and sealed.
- A complete drainage report coordinated and submitted with the plans and specifications.

The final draft of the design report must be submitted and the specifications book must be complete with the exception of "boiler plate" to be added prior to printing. The complete estimate of construction cost must be submitted.

(5) Final Submittal

This submittal is intended to provide proof of completion of design including incorporation of prefinal review comments. The drawings must be checked, signed, and sealed by the designer. Prints of this submittal are used to obtain concurrence to advertise for bids.

(6) Bid Documents

The original tracings and specifications are to be submitted. The submittal must be collated and ready for printing.

b. Quality Assurance Program

The quality assurance (QA) program is intended to verify that equipment, supplies, and work performed comply in all respects to the requirements as described in the contract documents and to assure the integrity of the approved design as defined by drawings. As such it must provide an effective system for ensuring that:

- All work performed for a project is performed in accordance with the engineering requirements.
- All equipment is tested throughout development, manufacture, and installation to verify that it functions as specified.
- Early detection of undesirable conditions is accomplished and positive corrective action is performed in a timely manner.
- Control over the configuration is maintained at all times to define the acceptability of equipment as established by design reviews, drawing approvals, and design verification testing and to preserve the configuration during retrofits and modification work.

The program should provide the documentation required to support the acceptance program. The owner should strive to minimize his detailed inspection of a contractor's work by rigid enforcement of the requirement for the contractor to have an effective QA program.

Quality assurance for design consultant contractors normally is handled through well established procedures for design production and review (see section C. 1. a.). The QA program described below was developed for other types of contractors. American National Standards Institute (ANSI) Standard Z1.8-1971, "Specifications of General Requirements for a Quality Assurance Program," was the basic reference document used in developing the program.

(1) Organization

The development and conduct of the QA program is the responsibility of the owner. Implementation is achieved by assigning responsibility to consultants and contractors. In all cases, overall auditing and surveillance of the program is performed by the owner. The organization structure and its interrelationships should be included.

(2) Technical Requirements

Technical requirements for the QA program should consist of the contractor's QA program, the owner's audit of the contractor's program, the surveillance of the work, the testing program, and the control of the configuration.

(a) Contractor's QA Program

Administration of the contractor's QA program should be vested in a responsible, authoritative element of the organization with clear access to management. Sufficient authority should be assigned to ensure that quality requirements are consistently maintained. There should be adequate planning, forceful direction, and control of the program.

To comply with ANSI Z1.8, it is necessary that the contractor's QA program address, as a minimum, the following 13 elements:

- Configuration Control--Documentation should be controlled to ensure that fabrication, installation, inspection, and testing are performed in a manner that meets the latest applicable requirements. All changes to the documentation package should be controlled to ensure they are approved. The configuration of all work should be known at all times.

- Inspection/Test Plans--Plans should be developed to organize inspection and testing to ensure adequate control over the work to verify acceptability. The plans should control the progress of work to provide evidence of acceptability and to discover nonconforming conditions at the earliest time and should ensure that preparations for inspection and testing are provided and that equipment, instrumentation, fixtures, and personnel are available when required.

- Nonconforming Materials--The inspection status of materials should be identifiable at all times, and the means employed to identify the inspection status should be controlled to prevent unauthorized use. Nonconforming materials should be segregated to prohibit their use, and procedures for the disposition of nonconforming material, including owner acceptance of rework and "use as is" decisions, should be established.

- Calibration--All measuring instruments and fixtures or gauges used in evaluating items for acceptance must bear evidence of calibration. A system should be employed to ensure that all such measuring devices are recalibrated at appropriate intervals and that out-of-calibration items are withdrawn from use. The standards used to perform calibration should have a known traceable relationship to the National Bureau of Standards.

- Procurement and Receiving Inspection--Adequate control over procurement sources should be maintained to ensure the incorporation of pertinent technical and quality requirements. Inspection and testing should be performed on procured materials, and adequate records should be maintained.

- In-Process Inspections and Tests--Sufficient control over work activities should be maintained to prevent nonconformance and excessive variability and to ensure compliance with requirements that can be verified only at the time and point of work. Inspections and tests should be performed in accordance with documented procedures that include acceptance criteria.

- Final Inspection and Testing--Inspection and testing of completed work should be performed to ensure that the quality requirements of the contract have been met. The inspection and testing should be performed in accordance with procedures developed by the contractor and approved by the owner. Test results should be recorded and submitted to the owner.

- Shipping Inspection--Provisions should be made to control the handling, preservation, and packaging of items to prevent damage, deterioration, loss, or substitution.

- Installation Inspection--A system of inspection should be employed throughout the installation work to ensure compliance with requirements. Records should be maintained to document which inspections were performed and whether the work conformed to requirements. All records should be available for the owner's review at the time of the owner's inspection and should be subject to audit at any time.

- Contractor Audit--Periodic audits should be conducted by the contractor to verify effective implementation of his QA program.

- Corrective Action--Records should be maintained for all inspections and tests. These records should include data concerning conforming and nonconforming conditions and should be reviewed periodically and summary information provided to the responsible management. Each owner-initiated record reporting unacceptable conditions should be evaluated fully. A response from the contractor to the owner should be required for each such record and should identify the cause, corrective action, and implementation

schedule. Prompt action should be taken to correct conditions that cause nonconformance, and an evaluation of the corrective action should be performed to measure its effectiveness.

- Documentation/Records--The contractor should maintain records of his QA program and these should be made available to the owner upon request. These records should include inspection and test results as well as the results of audits performed by the contractor to evaluate the effectiveness of his program.

(b) Owner's QA Audits

Owner QA audits conducted to evaluate the contractor's program should be performed at the source of manufacturing and should include selected supplies. They should involve a review of the QA system; verification of its implementation; and a status, documentation, and configuration evaluation of the hardware.

The audits should be based on applicable portions of the contract specifications, the referenced contract documents, the approved contractor QA program plan, and the owner's QA audit evaluation forms. The general procedure followed during the course of an owner audit should include an interview with the contractor's management to describe the audit process and arrange for coordination with the contractor's personnel; system, hardware, and inspection audits; an informal review of findings with the contractor's management; and a formal report on the audit issued through the office responsible for administering the contract.

During the audit of the contractor's QA program, the owner's resident or itinerant inspection activity is audited. The availability of contract specifications, approved drawings, inspection results, and test procedures is ascertained. Activity and inspection reports are reviewed and findings are documented.

Formal and informal audits are conducted throughout the program to verify that work conforms to the approved configuration. Formal audits are conducted at the time of qualification testing and on the first production items presented for shipment approval. Informal audits are part of the normal surveillance inspection activity.

(c) Contractor Surveillance

The owner should review all work pertaining to the manufacture and/or installation of equipment. For critical items and when the acceptability of an item can be verified only at the time and point of manufacture, in-process inspection should be performed. Equipment manufactured for the system should be inspected before the contractor is granted a "release for shipment." Installation work should be inspected at milestone events such as installation verification and after final testing.

The inspections performed should ensure that workmanship complies with requirements and conforms to industry standards, that the configuration of the equipment conforms to the latest approved documents and/or that deviations are identified, and that the contractor's documentation verifying acceptability is complete and adequate. To assure that all work performed complies with requirements, hold points for owner inspection should be established throughout the process of procurement, manufacture, and test. Resident or nonresident inspectors should be assigned to perform inspections, and a system of documentation should be employed to record data concerning the inspections performed and the findings.

The requirements should be defined by the specifications, contract drawings, approved contractor drawings, referenced standards, and related owner-approved documentation. Workmanship should be assessed in terms of the specifications and referenced standards; however, in their absence, the contractor's workmanship standards would apply if fully documented and not in conflict with general industry practice. Disagreements should be adjudicated by the owner.

An integral part of inspection is a review of the contractor's inspection records for the work being inspected. The records should demonstrate the contractor's QA verification of the acceptability of the equipment or work presented and the satisfactory completion of all appropriate prerequisites. Prerequisites are contractual events that must be satisfactorily concluded prior to the inspection. Typically, the hierarchy of prerequisites is as follows:

- QA program plan
- Reliability, maintainability, safety requirements
- Drawing approval
- Qualification tests
- Factory tests
- "Release for shipment" inspection
- Installation verification inspection
- Installation and system tests
- Final inspection.

Configuration verification is based on the engineering data that identify all drawings by revision level and date of issue in an indentured form and is supported by the owner-approved contractor drawings. This review ensures that changes in configuration are approved and properly identified as required by the specifications and that any deviations are known.

Documentation in the form of inspection reports should be utilized to identify the materials inspected, the point and time of inspection, the inspector, and the findings. These reports should be held on file for future reference and to support final acceptance.

Nonconforming conditions should be identified by the inspector on a "notice of rejection" (NOR) form. Deficiencies in the prerequisites related to the work or equipment under evaluation should be listed on the "prerequisite deficiencies" (PRD) report. The contractor should institute a "release for shipment" (RFS) form for each shipment. Approval of the RFS form is granted by the owner. An inspection report (IR) documents each inspection and identifies actions and reports issued.

Subcontractor surveillance inspection should be performed by the owner on a selective basis. The criteria for selection may include the complexity of the work, the uniqueness of the design, and the potential impact of problems on the project schedule. All owner inspection of subcontractors should be coordinated with the contractor. Unacceptable conditions discovered during the inspection should be identified for the subcontractor and reported to the contractor for resolution. Inspection of the subcontractor's work by the owner does not relieve the contractor of any responsibility for his subcontractors.

Hold points established on the work by the owner may be altered from time to time at the owner's discretion. A hold point is defined as a point in the progress of work (through manufacture, shipping, installation, and testing) at which further progress must be held pending inspection and concurrence by the authority to proceed. Hold points should occur at least prior to shipment or transfer of subassemblies, assemblies, or subcontracted work from one facility to another or to the site and prior to tests that follow installation work. The contractor should make available to the owner's inspectors at the time of inspection evidence of the contractor's inspection and acceptance of work performed prior to the hold point.

Resident inspectors may be assigned to manufacturing facilities if the work to be performed is unique, critical, or complex; involves a high degree of new design; or is long-term in duration with frequent shipments that make nonresident inspection impractical. Hold points should be established for in-process inspection by the resident inspector in concurrence with the owner and coordinated with the contractor. All contractual tests performed by the contractor at the manufacturing facility should be witnessed. As noted above, inspection should be performed on all materials presented for shipment, and surveillance should be maintained to ensure compliance with the configuration control requirements of the contract.

Nonresident inspection provides for surveillance over work performed at the place of manufacture if a resident inspector is not assigned. This activity generally is restricted to inspection of materials presented for shipment. At the owner's direction, the nonresident inspector may be required to witness tests performed at the facility under surveillance. At the time of test witnessing

and inspection, the configuration should be reviewed to ensure compliance with contractual configuration control requirements.

Installation inspection provides for surveillance over the receipt, movement to position, and installation of equipment and systems. Inspection hold points would occur prior to installation verification tests, final tests, and acceptance. Inspections should be performed at such critical events during installation as cable pulling, cable terminating, equipment installation, and conduit and wire tray installation. Surveillance should be provided to ensure conformance to the contractual configuration control requirements. All field modification and retrofit work should be performed under the surveillance of installation inspectors.

Spare parts should be inspected when received except when a shipment of spare parts is made by a facility under resident inspection or when its receipt coincides with a nonresident inspection visit. Spare parts are subject to the same criteria and documentation requirements outlined above. Parts should be placed into stock only when there is evidence indicating their acceptability.

(d) Testing

Tests should be performed throughout the cycle of development, manufacture, installation, and acceptance to verify that products, subsystems, and systems conform to functional requirements. The contractor should plan the sequence of testing to ensure that adequate time is scheduled and that facilities and personnel are available. All tests should be performed in accordance with detailed procedures and test results should be recorded. The contractor should develop the plans and procedures, perform the tests, and record the test results. The owner should review and approve the contractor's plans, procedures, and test results and should witness the tests to verify performance. The following tests should be performed as indicated:

- Qualification Tests--A qualification test should be performed on products and subsystems to demonstrate that the design complies with the specifications. These tests should be satisfactorily concluded prior to the initial delivery of the item.

- Factory Tests--Prior to shipment from the point of manufacture, functional tests should be performed on assemblies, subsystems, and systems to verify that the equipment to be shipped complies with the specifications.

- Installation Verification Tests--These tests should verify that equipment has been satisfactorily installed. Physical inspection, circuit continuity, insulation resistance, and power-on tests should be included.

- System Tests--System level tests should be conducted to demonstrate that the installed system is free from damage due to shipment and installation and that the equipment performs in accordance with the specifications. These tests should be performed after completion of the installation verification tests.

- Integrated Tests--After completion of the system tests, integrated tests should be performed to demonstrate that the system performs satisfactorily when connected to interfacing systems or subsystems.

- Prerevenue Tests--A series of tests should be performed using revenue service operating procedures to demonstrate the compatibility of the physical transit system and operating procedures.

(e) Configuration Requirements

Configuration requirements include the following:

- Indentured Bill of Material--Contractors should be responsible for preparing an engineering data package that establishes the production baseline. Included should be a data list comprising an indentured list of all engineering drawings to the lowest level of repair and replacement by revision or issue and containing all documentation necessary to define and identify the approved baseline configuration. This list is a prerequisite to qualification testing and should be maintained current throughout the program.

- Serialization Records--When serialized equipment is installed, the contractor should maintain serialization as well as configuration records for each installation. A copy of these records should be supplied to the owner at the time an RFS form is initiated by the contractor. The contractor should maintain these records current at all times.

Changes to the approved baseline should be controlled through a rigid system utilizing engineering change proposals, configuration control review and disposition, and issuance of a formal change order. The contractor's program should ensure that all changes are processed in accordance with these provisions. Implementation of all approved changes, modifications, and retrofits of delivered hardware may be performed by the contractor after informing the owner about the modification and after submitting to the owner all drawings and associated documentation that define the change, modification, or retrofit. All such work should be performed under owner inspection.

Changes affecting the following require prior owner approval:

- Performance outside stated tolerances
- Reliability or maintainability
- Physical or functional interchangeability
- Interface characteristics
- Test programs, procedures, connections, instruments, or documentation
- Weight or balance (where it is a factor)
- Safety
- Electromagnetic interface characteristics
- Computer programs for operation, test, or maintenance
- Compatability with support or training equipment
- Delivered products (retrofit)
- Delivered training, operation, maintenance, or overhaul manuals (when additional funds are required to revise manuals)
- Present adjustment or schedules affecting operating limits to such an extent as to require new identification
- Source of repairable items (source control drawings)
- Schedule or deliveries
- Spare parts provisioning
- Owner-furnished equipment.

Any engineering change not affecting form, fit, function, or interchangeability and not affecting the above items should not require prior owner approval.

Deviations and waivers apply to all nonconforming conditions that are limited in nature and not considered to be permanent changes and require prior owner approval. Deviations should be requested prior to manufacture for a limited and specified number of units for a specific period of time. Waivers should be requested for specific nonconforming conditions on specific terms during production or inspection. Any deviation or waiver granted must be included in the RFS documentation at the time of an RFS form is initiated. When the request is based on a "notice of rejection" (NOR), it should be identified. A deviation or waiver of design characteristics identified in approved drawings requires the approval of the managing engineer and the concurrence of the quality assurance manager. Deviations or waivers concerning workmanship require the approval of the quality assurance manager. A deviation or waiver concerning the contract specifications and drawings should not be allowed.

(3) Program Management Requirements

The owner's QA unit is responsible for implementation of the QA program. To ensure that the program is fully and successfully implemented, auditing, monitoring, and witnessing activities should be assigned to those groups within the organization having the

required expertise, and an organization chart should describe their relationships. The functional responsibility assignments are described below:

(a) Owner's QA

- Review and recommend approval of contractor quality-related submissions
- Audit the activities of all systemwide work in production and installation
- Review and approve all source inspection activities in advance
- Witness critical events such as qualifications tests, first-article submissions, final tests before shipment, installation verification tests, and system tests
- Process all deviation and waiver requests, approve workmanship-related requests, and obtain concurrence from engineering groups as appropriate
- Review and approve all RFS requests
- Review and concur in payment and system acceptance
- Monitor and audit the implementation of configuration management system
- Review and concur in all personnel manning and changes in QA program implementation
- Provide direction to other quality control groups in implementing program and adjudicate all rejection disputes between contractors.

(b) Quality Control

- Develop procedures and check lists for the inspection and test observations to be performed on all contracts
- Provide for resident inspection at the source of production for contracts or subcontracts in accordance with owner's QA program
- Provide for nonresident inspection at the source of production in accordance with owner's QA program
- Function as the central point for receiving and disseminating information on quality-related matters
- Report on and document functions performed
- Perform surveillance at the source of manufacture and recommend approval of RFS requests
- Recommend approval of waivers for workmanship
- Maintain quality and configuration records and provide routine summary and/or detail reports as required by owner
- Oversee the receipt of equipment, inspect for shipping damage and completeness, and recommend acceptance
- Provide for inspection of all physical installation work up to and including all wiring, piping, etc., and associated continuity checks
- Control the implementation of all changes, modifications, and retrofits on delivered hardware and provide for inspection of the completed work

- Organize, implement, and conduct the activities of the configuration change control board.

(c) Systemwide Engineering

- Witness qualification testing performed by contractors and their subcontractors on end items (qualification testing performed for contractors or their subcontractors by certified testing laboratories will be witnessed on an exception basis only)
- Review and approve the completeness and acceptability of all testing procedures
- Review and approve all test reports
- Witness functional testing of first-article submissions for acceptance of complex hardware
- Witness special evaluation tests
- Witness installation verification and final tests for acceptance of delivered vehicles and supervisory and control, traction power, and train control equipment
- Monitor any changes introduced during testing to ensure that they are properly documented and reported in accordance with approved procedures
- Review and recommend system acceptance.

(d) Owner's Program/Construction Management

- Approve deviation and waivers, except those involving workmanship, and support QA in evaluating workmanship deviations
- Concur on recommendations for approval for payment and final acceptance
- Witness testing as required
- Review and concur on test reports verifying acceptability
- Review and approve test procedures.

(e) Owner's Test Director

- Review and comment on the completeness and acceptability of all functional testing procedure submittals
- Review and comment on all test reports verifying the acceptability of the reported results
- Schedule, organize, and direct the activities for interfacing subsystems or systems to permit system testing
- Provide direction for and surveillance over all integrated testing and prerevenue testing activities
- Review and recommend system acceptance
- Organize and direct the on-site acceptance tests performed by the owner
- Witness major subsystem preshipment testing, as required.

(f) Owner's Operations Department

- Support the warranty program by maintaining equipment
- Receive and inspect incoming material and supplies delivered to

the owner, such as maintenance equipment, supplies, and spare parts (this does not include construction division contracts)
- Support integrated and prerevenue testing with operating personnel.

(4) Documentation

Documentation should include the items listed below:

(a) Contractor Documentation

- QA program plan
- Manufacturing plan
- Configuration management plan
- Test plans, procedures, and results
- Indentured parts listing
- Configuration and serialization records
- Deviation/waiver requests
- RFS requests
- Notices of modification.

(b) Owner QA Program Documentation

- Configuration status reports
- Prerequisite deficiency reports
- RFS forms
- Notices of rejection
- Inspection reports
- Notices of modification
- Deviations and waivers.

2. Cost Control

The following excerpt from "Construction Cost Control During Design of Major Transit Systems," a paper prepared by Henry F. Padgham and Howard J. Chaliff (Parsons Brinckerhoff/Tudor, Atlanta, Georgia) for presentation at the February 1980 meeting of the Project Management Institute in Miami, Florida, describes aspects of project cost control used on the Metropolitan Atlanta Rapid Transit Authority (MARTA) project and provides an example of how cost control techniques have been applied.

Accounting for and Tracking Costs

Establishment of a flexible work breakdown structure (WBS) and its numbering system is essential for projects having the linear construction characteristics of transit systems. The first task of the project control group was developement of the WBS. Our requirements were that it must:

1. Function as the project chart-of-accounts for job costs
2. Function as the job work order numbering system for making job assignments with definable end products and single points of responsibility
3. Be completely flexible to accommodate the evershifting scope definition of the project
4. Be easily understood by the many people coming in contact with it.

The system has met all these goals and we have had virtually no trouble with its acceptance and use throughout the MARTA/General Engineering Consultant (GEC) staffs. The system is keyed principally to geographic segments of the system that are established as construction contract units (CCUs). The project map, Figure 6, shows the basic geographic breakdown structure and its numbering system. From this, by addition of a preceding alpha prime account designator, the basic work order account number is established. These work order numbers are used then as a construction contract number, a design assignment work order number, an account number for accumulating construction management inspection services for a particular contract, or for any other requirement where separate accounting and cost pinpointing is required. The basic numbering structure is shown in Figure 7. Figure 8 is an extract from the project contract unit description publication (maintained on a current basis) that ties the project scope and WBS system together. The system works well mainly because it is so flexible and adaptable to such things as changing contract interfaces and combining or splitting of contracts as dictated by the project environment. The decisions regarding dollar size and work scope make-up of the contracts are subject to considerable change over the course of the project until contract award is made. These decisions are influenced by such factors as:

1. Dollar size, to attract minority business contracting
2. Type of labor rates applicable to a project (heavy-highway rates versus building trades rates)
3. Early release to construction for community visibility
4. Change in concepts (e.g., cut and cover subway to tunneled subway)
5. Restaging of construction to work around unavailable rights-of-way.

The tracking of project costs is through computer-based reporting systems that are typical of most large construction projects and include various detail and summary level reports depicting budgetary, incurred, and forecast cost information in various arrays. Of interest in this discussion on cost control during design is the monthly cost status report shown in Figure 9. One page is used for every active CCU under design. It may seem like a lot of data, but it resulted from the communication frustrations that often arise between the project managers and the program cost and schedule groups. Figure 10 shows the same report with indicators of the number of parties responsible to complete the report. It has solved a lot of communication problems regarding the cost-schedule status of a project under design.

Estimate Handling

Figure 11 shows the evolutionary flow of a design assignment through its milestones and attendant support estimating. Like many project control systems, it looks good on paper but, in practice, getting it to function properly is quite another matter. The MARTA project is no exception. We have suffered from the usual problems such as:

1. Insufficient scope and related estimate clarity at the early milestones, particularly at the conceptual levels
2. Too much "SWAG" estimating on the original allocation estimates
3. Too much attention to the engineers' estimate because of its outside visibility
4. Insufficient discipline in maintaining the trending system between milestone estimates.

We have worked hard to overcome these problems and our system is working well today.

As shown on Figure 11, milestone estimates are required at six points during the course of design, beginning at the conceptual level and culminating with the engineers' estimate. The milestone estimates are complete estimates with full detail quantity take-offs, priced at the best known current market conditions, and escalated to the then-scheduled midpoint of construction. On the MARTA project escalation is folded into every budget line item from the original allocation estimate forward and must be dealt with at individual CCU levels at every estimate stage. Designer construction budgets thus include escalation as part of the design subcontract contractual cost limitation against which no-fee redesign provisions are written. Including escalation in individual line items eases the overall handling of project budgeting from the MARTA viewpoint, particularly in the area of administering the remaining contingency fund. Budgeting escalation in the designer's budget increases his coordination efforts to assure that it is continually updated for rate and construction schedule change effects. The project trending estimates are order-of-magnitude estimates of individual trend items. Trend meetings are conducted monthly for every contract under active design.

Engineers' estimates are prepared as much as possible as if the estimators were bidding the job. MARTA relies on a single number (not a range), so prepared, to assess the cost responsiveness of bidders. The engineers' estimate thus receives high visibility and tends to come in for great criticism if not fairly representative of the bids received. This puts a good deal of pressure on the estimating staff, partly of a political nature, and detracts from devoting attention to the latest milestone estimates. From a procedural point of view the prefinal estimate, adjusted for bid period addenda, should suffice as the engineers' estimate. The most salient value received from doing a formal engineers' estimate during the bid period is tuning the estimate refining to current market price conditions received by the estimator.

Parameter estimating for the milestone estimates on the MARTA project has been tried and has not been effective, except for certain types of line segments and line related equipment. The transit stations in general are too significantly different to obtain reasonable estimates on volume square footage parameters.

Getting the Designer To Be Sensitive To Construction Costs

The project manager is on a day-to-day working relationship with the section designer. If the section designer has a local office, the project manager will visit the office at least once a week. If the office is out-of-town, the project manager will visit the office at least once every three weeks. At these periodic visits, the project manager will review the progress of design--either by himself or with the assistance of one or more of the GEC technical staff. Not only are the documents reviewed for completeness but also for the purpose of identifying new construction elements, which are present in the design, over and above those identified in the conceptual design (e.g., a new retaining wall, additional drainage, new architectural features, or some new mechanical or electrical criteria that must be incorporated).

When a new element of construction is identified, the project manager prepares a request for a cost trend estimate and sends it to the GEC estimating department for an order of magnitude estimate. This value is circulated to the client (MARTA) and the additional costs are added to the previously determined cost estimate; this becomes the current forecast. Changes in escalation rates and construction schedule changes also are trended.

The project manager throughout the project is concerned with the costs and schedules; in the back of his mind is the ever-present cost limitation. When the present forecast approaches the cost limitation, the project manager begins evaluating the project to see where construction costs can be reduced and still maintain the integrity of the design. Since the section designer is on a lump sum type contract, care must be taken not to inject more cost extras into the design than are saved in construction costs. Often the cost can be reduced by material substitution, such as architectural concrete instead of stainless steel closure panels, quarry tile floors instead of granite pavers, replacing walls by earth slopes in areas where the right-of-way is, or can be made, readily available.

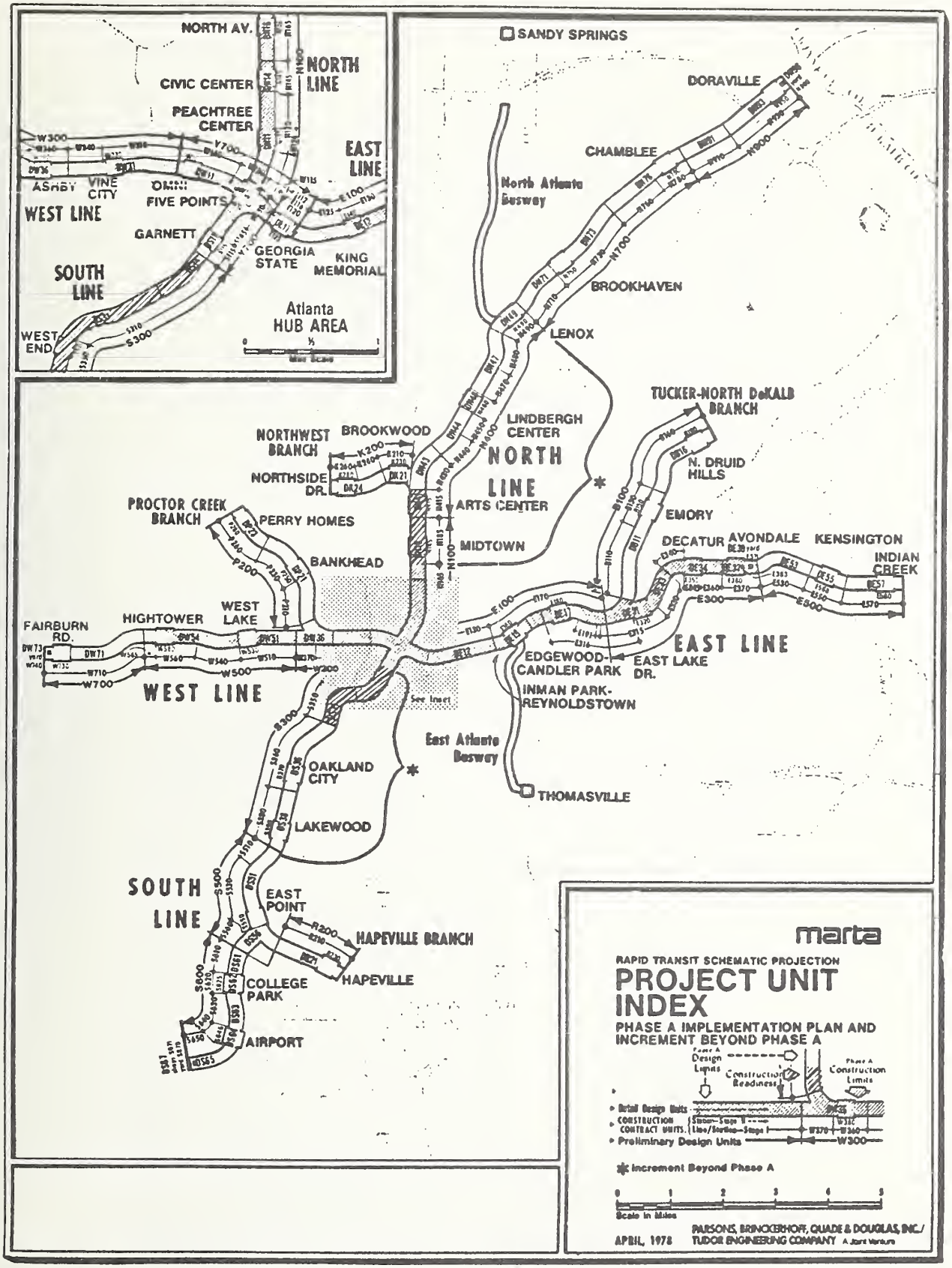


FIGURE 6. PROJECT MAP

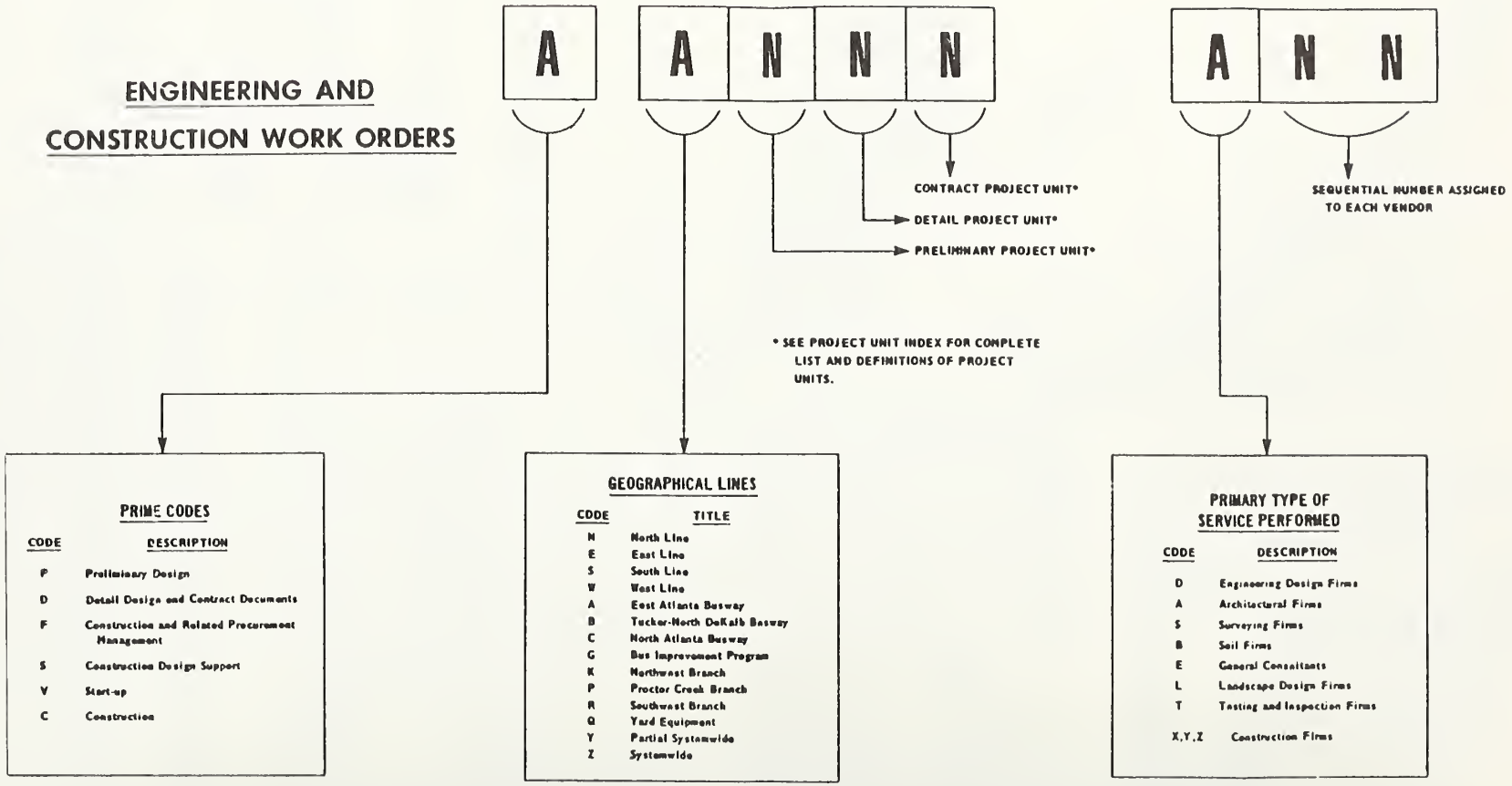


FIGURE 7. WORK BREAKDOWN STRUCTURE NUMBERING SYSTEM

West Line

Five Points Station to Fairburn Road Station
& Proctor Creek Branch

Prelim. Design Unit	Detail Design Unit	Construct. Contract Unit	Type of Construct.	Length In Feet (Approx.)	Type	Description	Stationing From - To
W100							
	DW10						
		W110	At Grade/ Subway	361	Struct/ Station	Portions of the Five Points Station construction coincident with viaduct reconstruction at S. Peachtree and Forsyth Sts., including 175 feet of the Interline Connector, plus a temporary relocation of the railroad Wye in the vicinity of Forsyth St.	ER2+23-ER3+39 WR2+23-WR2+93 X9+55-X11+30
		W115	At Grade/ Subway	1,379	Line	That portion of the West Line running from the east end of Five Points Station to a point about 135 ft. east of the east edge of Courtland Street; and, including a portion of the MARTA Interline Connector.	ER3+39-ER17+18 (Eq: ER17+18=ER17+15)
				955 (Interline Connector)			X0+00-X9+55
		W130	Subway	653 (E-W)	Line & Station	That portion of the West Line running from 50 ft. east of the east edge of Fairlie St. to the east end of Five Points Station, including Five Points Station construction, and that portion of the North-South Lines, lying between the north side of Martin Luther King, Jr. Drive and a point 80 ft. south of the south side of Marietta Street, and including a portion of the MARTA Interline Connector.	(E/W) WR5+00-ER3+39
				990 (N-S)			(N/S) SR6+15-NR3+75
				555 (Interline Connector)			X11+30-X16+85
			(Subway	(E/W) 600 (N/S) 600	Station	Five Points Station.)	(E/W) WR2+61-ER3+39 (N/S) SR4+25-NR1+75
	DW11						
		W140	At Grade/ Subway	2,000	Line	That portion of the West Line running from a point about 80 feet east of the center line of Mangum St. to a point 50 ft. east of the east edge of Fairlie St. including	WR25+00-WR5+00

FIGURE 8. CONTRACT UNIT DESCRIPTION EXTRACT

LAST DESIGN SUBMITTAL WAS BID DOCUMENTS

DATE OF LAST SUBMITTAL 11/79

COST PROGRESS STATUS REPORT DATE 11-20-79

CCU N/BS

DESIGN COST DATA

	ORIGINAL ESTIMATED DESIGN BUDGET A	CURRENT APPROVED DESIGN BUDGET B	COST TO DATE OF THIS REPORT C	CURRENT FORECAST TO COMPLETION D	VARIANCE D - B	TREND FROM PREVIOUS MONTH	REMARKS
A&E	661,770	779,761	769,761	779,761	- -		
DATE BUDGET ESTABLISHED FOR A&E	3/78	10/79	10/79	10/79			
PB/T	238,400	343,525	318,520	400000	56,475		COST TO PREPARE ADDENDUM REV BY'S OF AT MARTA FOR APPROVAL.
DATE BUDGET ESTABLISHED FOR PB/T	2/78	11/79	10/79	11/79			
ARE CURRENT CHANGES INCLUDED? SPECIFY IN REMARKS COLUMN				YES			

DESIGN PROGRESS

	CURRENT APPROVED DESIGN SCHEDULE	CURRENT FORECAST TO COMPLETION	VARIANCE		TIME REMAINING TO SUBMIT BID DOCUMENTS BASED UPON APPROVED SCHEDULE	"0" = THIS ITEM DOES NOT APPLY TO THIS REPORT
A&E	9/79	9/79			% OF WORK YET TO DO	— %
PB/T	10/79	12/79			% OF CURRENT APPROVED BUDGET (C/B) AVAILABLE	— %

CONSTRUCTION COST DATA

	APPROVED CURRENT BUDGET ESTIMATE A	PROJECT DEFINITION ESTIMATE B	A&E COST TARGET/ LIMITATION C	PRELIMINARY DESIGN ESTIMATE D	30% FORWARDED DETAIL DESIGN ESTIMATE E	PRE FINAL DESIGN ESTIMATE F	ENGINEER'S ESTIMATE G	CURRENT FORECAST H	VARIANCE J = H-A	TREND FROM PREVIOUS MONTH	REMARKS
ESTIMATE (000)	26,348 ①		23,500	26,587	26,340	26,348		27,676	1328		LAST TREND SHOULD BE SUBMITTED 6 / LAST TREND SHOULD BE PLOTTED 6
DATE PREPARED			3/78	2/78	10/78	1/79		11/79			
CONSTRUCTION DURATION IN MONTHS				23	23	24		26			
CONSTRUCTION MID POINT MONTH/YEAR				2/80	2/80	8/80		3/81			
IS COST ESCALATED TO MID POINT?				YES	YES	YES		YES			
ARE CURRENT CHANGES INCLUDED? SPECIFY IN REMARKS COLUMN											

① MARTA HAS NOT APPROVED THE SUBMITTED CHANGE REQUEST TO INCLUDE ALL SYSTEMWIDE ELEMENTS. THE BUDGET SHOWN IS PENDING APPROVAL.

LAST ADDENDUM 12/3/79 NTP 1/28/80

FIGURE 9. MONTHLY COST STATUS REPORT

LAST DESIGN SUBMITTAL WAS PM

DATE OF LAST SUBMITTAL PM

COST PROGRESS STATUS REPORT DATE

CCU PM

DESIGN COST DATA

	A	B	C	D	D-B		REMARKS
A&E	PM	PM	PM	PM	PM	PM	PM
DATE BUDGET ESTABLISHED FOR A&E	PM	PM	PM	PM	PM	PM	
PBIT	PM	PM	PM	PM	PM	PM	
DATE BUDGET ESTABLISHED FOR PBIT	PM	PM	PM	PM	PM	PM	
ARE CURRENT CHANGES INCLUDED? SPECIFY IN REMARKS COLUMN	N/A	PM	PM	PM	PM	PM	

DESIGN PROGRESS

A&E	PM	PM	PM		% OF WORK YET TO DO	PM %
PBIT	PM	PM	PM		% OF CURRENT APPROVED BUDGET (A) REMAINING	PM %

CONSTRUCTION COST DATA

	A	B	C	D	E	F	G	H	J = A-H		REMARKS
ESTIMATE ($ 000)	CE	EST	EST	EST	EST	EST	EST	CE	CE	CE	LAST TREND INPUT IN SUBMITTED: PM; LAST TREND INPUT IN ESTIMATE: EST
DATE PREPARED	CE	EST	EST	EST	EST	EST	EST	CE	N/A	N/A	EST, SCH, CE
CONSTRUCTION DURATION IN MONTHS	CE	SCH	N/A	SCH.	SCH	SCH	SCH	SCH	SCH	SCH	
CONSTRUCTION END DATE MONTH/YEAR	CE	SCH	N/A	SCH.	SCH	SCH	SCH	SCH	SCH	N/A	
IS COST ESCALATED TO THIS POINT?	CE	CE	N/A	CE	CE	CE	CE	CE	N/A	N/A	
ARE CURRENT CHANGES INCLUDED? SPECIFY IN REMARKS COLUMN	N/A	PM/EST	N/A	PM/EST	PM/EST	PM/EST	PM/EST	PM/EST	N/A	N/A	

A. RESPONSIBILITY TO COMPLETE THIS FORM
1. PM = PROJECT MANAGER
2. EST = ESTIMATING
3. SCH = SCHEDULING
4. CE = COST ENGINEERING

B. COORDINATION RESPONSIBILITY: COST ENGINEERING

C. REVIEW RESPONSIBILITY PRIOR TO PUBLICATION: PM, DIV. MANAGER OF ENGINEERING, DIV. MANAGER OF PROJ. SERVICES

D. UPON PUBLICATION, REVIEW WITH MARSA RESPONSIBILITY: DIV MANAGER OF PROJECT SERVICES

FIGURE 10. MONTHLY COST STATUS REPORT WITH INDICATORS

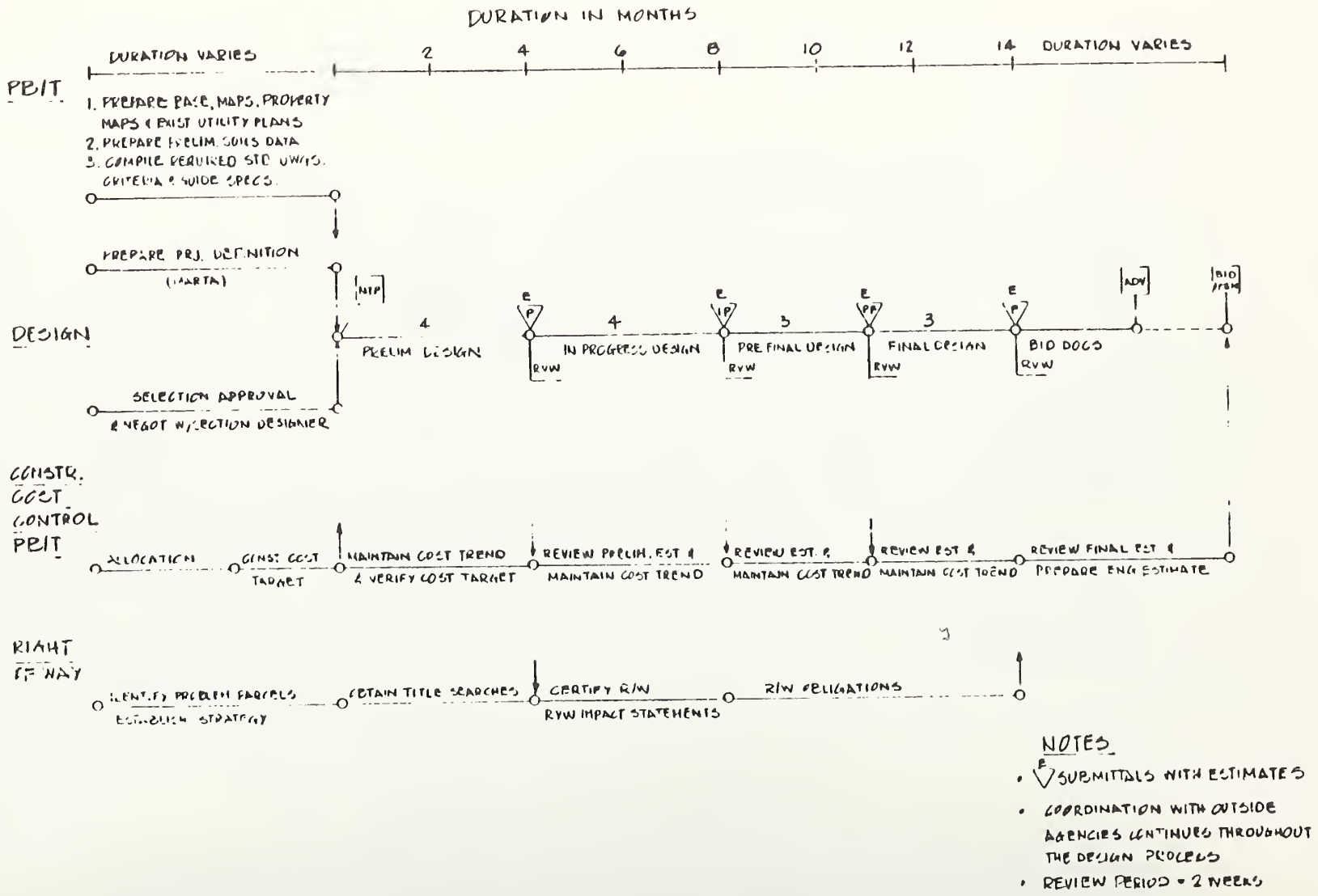


FIGURE 11. TYPICAL DESIGN EVOLUTION THROUGH MILESTONE ESTIMATES

One of the primary ways to save on the cost of the project is to complete the design and advertise the project on time. With a current annual rate of inflation of 12 to 13 percent, a delay means additional construction dollars. MARTA had received a federal grant of $800 million toward their Phase A Long Range Program of $1,017,000,000. As long as the total cost of construction stayed within that number, MARTA was only funding the project with local funds to the tune of 20 percent, while UMTA was paying 80 percent. When the $1,017,000,000 figure was exceeded, MARTA had to use 100 percent local funds to finance that portion of the project over the budget. There were a few exceptions when MARTA, under the federal guidelines, was allowed to reclaim for additional funds such as those for excessive right-of-way settlements and for construction escalation rates higher than planned. However, delays to advertising and putting a contract under construction were not acceptable for additional funding.

Every milestone submittal is accompanied by a cost estimate which is closely evaluated as it relates to the cost limitation. At the preliminary level the project is essentially defined as to its exact size, room locations, dimensions, elevations, materials, finishes etc. The preliminary estimate is evaluated to determine if it is within the cost limitation. If it is not, the project is closely scrutinized to determine if cost reductions can be effected. As a matter of course, this would be done even if the preliminary design cost were under the cost limitation. After all cost reductions are implemented and PB/T [Parsons Brinckerhoff/Tudor] and MARTA are convinced that this project is the most cost effective, the preliminary design cost estimate becomes the basis of the new cost limitation. The new cost limitation will be carried forward for the balance of the design project. If the cost limitation is exceeded without approved scope changes, the section designer may be required to redesign the project at his own cost.

The Pitfalls of Changes and Delays

The project definition (conceptual design) of stations is presented to the section designer in a very basic form. The owner and GEC staffs have blended the functional layout of the required spaces with the most effective movement of passengers from the parking lot, "kiss-ride" lot, bus "drop-off", or walk-in patronage. Not a great deal of time is spent during this state in the architectural details other than projecting an image of the stations; i.e., to try to configure the station in a way that will be compatible with the surrounding landscape and the community.

The actual architectural design is performed by the section designer. It is in the early stages of detail design that the section designer often gets into trouble. His natural inclination would be to look for a better or perhaps a more economical solution as well as to try to reflect his own ideas as to the station configuration. This in itself is not bad since that is part of his assignment. However, the project definition is prepared on the basis of the design criteria and knowledge gained through years of station design.

While the section designer is encouraged to evaluate the project definition and try to improve it, close coordination is necessary at the early stages to guide the section designer along his way. Some section designers spent so much of their time and budget during the early investigation stage that they ran into financial difficulties later. Although the new contracts with section designers are lump sum, early consumption by the designer of his budget is of concern to PB/T because the result can be an incomplete design package which will ultimately delay the project.

The project manager constantly is fighting the battle of changes. Changes cause delays, and delays cost the client valuable dollars. During the course of design and construction certain items are identified as needing change because we found in construction that they simply would not work due to existing or changing field conditions.

The project manager must be cognizant of these items and as soon as possible try to get them incorporated in the design. If the design does not include the change, then a change notice (CN) will be required during construction. This CN will invariably cost many times what it would have cost had it been incorporated in the design prior to bid advertisement. Besides the exhorbitant cost of incorporating the new item in the construction, the client could be burdened with a claim for extended overhead by the contractor for delay incurred.

Throughout the project many engineers or architects will try to interject some of their own ideas into the ongoing design. The project manager must evaluate each request for change to determine if the change is warranted and if the additional cost would be justified by the change. At times, the project manager must take a hard line and allow no changes unless the request comes from the highest level of company management.

Cost Limitation; Is it Effective?

During the early years of the project, the CCU budgets came from the initial allocation budget estimates and the section designer was furnished this as a cost target for which he was to make his best effort to stay within. The cost target was a dollar value which was 10 percent lower than the budget. The section designer had a cost-plus-fixed-fee contract and there was no contractual provision for no-fee redesign if the estimates of the final package exceeded the cost target. This process prevailed during the early life of the design program and proved to be unsatisfactory.

The cost target concept was changed in favor of the cost limitation. As discussed earlier, the cost limitation is based on an itemized estimate of the conceptual design. The section designer's final package cost estimate, when increased by 10 percent, cannot exceed the cost limitation without redesign penalties. At the preliminary design state, the cost limitation is again evaluated.

Section designer contracts are now lump-sum contracts, which contain a clause for redesigning at the section designer's cost if the cost limitation is exceeded. During the course of the design, monthly cost trend meetings are mandatory and are conducted by the project manager. This system, working in conjunction with the cost limitation program has proven very effective in controlling construction costs during design.

3. Schedule Control

The critical path method (CPM) is a method of planning, scheduling, replanning, rescheduling, and progress evaluation that facilitates the performance of the project team for planning, design, and construction. A full CPM program involves network diagrams and supporting data.

A network diagram serves as a visual presentation of the sequence of activities needed to fulfill project requirements. As such, it should:

- Show graphically, in logical sequence, each of the activities necessary to complete the project or project phase.
- Identify the starting point, duration, and ending point of each activity.
- Show all interfaces (i.e., interdependencies and relationships with operations of other consultants, contractors, and suppliers and subnetwork diagrams). (The information needed to show such interfaces with operations of other consultants, contractors, and suppliers should be furnished by the owner.) The CPM program further involves any modifications that may be required by changes and the updating of network diagrams and their supporting data to report actual progress and current status of the project. Consultants and contractors should indicate on the network diagrams interim fixed starting or completion dates for portions of the contract.

The supporting data for a network diagram should consist of a computer print-out or an equivalent listing that provides the following information for each activity:

- Starting and ending node numbers
- Duration
- Description
- Early start and late start dates
- Early finish and late finish dates
- Total float time.

The reports generated as part of the CPM program should be reviewed continuously and used as working tools by the consultants and contractors. The consultants and contractors should furnish any information requested by the owner for his evaluation of the performance under the contract (including but not limited to manpower loading charts and equipment schedules) and should submit to the

owner an updated network diagram and supporting data at least once a month. The updated network diagram should be prepared in accordance with the following:

- All such activities should be updated and reported on as of the same date.
- All updated data should be furnished in the form required by the owner.
- The updated diagram should indicate completed activities, any revision of the logical sequence of the activities, and the most critical path of activities based on the current update.
- The supporting data for the updated diagram should consist of a listing of the actual starting dates for each activity in progress and actual starting and completion dates for all completed activities and an analysis of completion date changes that identifies which activities contributed to the changed completion dates and why.
- The supporting data also should contain all information needed to indicate the current status of the project including design policy memoranda or other technical data issued by the owner or his representative; design development in prime contracts and specialty procurement contracts which necessitates revision to current contracts; changes required by utility companies or local agencies during the course of construction; finalization or revision of agreements between the owner and public agencies; revisions to right-of-way agreements; and revisions necessary to accommodate changed or unforeseen field conditions or changes at interfaces of adjacent contracts.
- Alternative designs proposed by contractors for their convenience or as cost-reduction proposals should be reviewed. If the effort to review these changes is expected to exceed one man-day, the resident engineer should be notified.
- Assistance should be provided to the owner in negotiations relative to agreements with public agencies.
- Where utility relocation by the utility agency precedes award of the construction contract, it may be necessary to provide coordination with field work.
- The design office should coordinate the work of project architects and engineers under subcontract regarding their design services. Working drawing submittals may be made directly to the architect or engineer under subcontract with a copy of the submittal form to the designer. In returning the corrected submittal to the resident engineers, the designer will review the subcontractor's comments, coordinate with other subcontractors if necessary, and countersign the approval stamp to indicate all coordination has been accomplished.

4. Change Control

During the preliminary design phase of a project, design criteria should be developed sufficiently to permit the design of basic

system elements to be firmly established for the final design. Deviations from the design criteria should be made only for compelling reasons, not for expedience. Criteria changes made while the final design is being prepared generally result in extensive revisions to final design drawings and in configuration problems with permanent equipment on order. Such changes adversely affect morale among design personnel and result in duplication of previous engineering efforts--all of which tends to result in delays, extra costs, and inefficiency.

During the construction phase, revisions of the design or even redesign may be necessary to accommodate unanticipated site conditions, accepted value engineering proposals, final manufacturer's drawings, errors, and other factors. Procedures should be developed for solving design and field problems as they occur during construction. These procedures should be clear and achieve results rapidly.

Procedures that have been used by design offices during the construction phase of contracts are described below.

a. Review of Working Drawings

Working drawings normally should be submitted to the design office for technical review. Drawings of no design significance may be reviewed and approved by the field office and so identified before they are sent to the design office. In this case, field office approval should be adequate unless the design office responds within a specified number of days.

Steel company placement drawings should be reviewed to ensure that they reflect the design intent and clearly indicate complete reinforcing placement including bar sizes, configuration, spacing, splice and anchorage lengths, and details of joint and special conditions. The intent of the placement drawings review is to ensure that these drawings can be utilized effectively by the field staff in checking reinforcing steel placement. It is expected that the contractor will comply with standard drawing practices. This includes provisions for separate placing drawings that identify the location of all bars in plan or elevation and clarifications of sections wherever the outline changes. An arrangement of the entire structure should be included and should reference clearly other parts of the structure to those detailed. All splices and anchorage lengths should be indicated clearly. Working drawings should be checked in the vendor's office prior to submittal; unchecked drawings should be returned to the vendor.

Steel fabricators' detailed drawings should be reviewed to ensure that material types and sizes, basic dimensions, locations of splices, weld and connection details, and other miscellaneous

items are in conformance with the contract documents. The designer should check for strength but not for detail dimensions.

Temporary support drawings should be reviewed to ensure that the basic design is in accordance with established criteria, that the loads and assumptions are valid, and that the recommendations of the soils report have been considered. The compatibility of the proposed work with other adjacent construction at contract interfaces also must be assessed. A more detailed review may be necessary if the temporary support appears to be unsatisfactory.

Mechanical and electrical material lists, shop drawings, and catalog cuts should be reviewed to ensure that the material or equipment meets the requirements of the plans and specifications with regard to quality, rating, and capacity. They should be checked by the contractor prior to submittal.

Miscellaneous shop drawings should be reviewed to ensure conformance with the drawings and specifications.

b. Interpretation of Contract Drawings and Specifications

Questions by the resident engineer concerning interpretation of contract drawings and specifications generally are resolved by discussion. However, if additional details are required, they are provided through the issuance of change notices. Omissions, conflicts, or other inconsistencies in the plans or specifications are rectified by the issuance of a change notice or are dealt with on the "as-built" drawings if the conflict is of a minor nature and the vendor prints, checked by the design office, are correct. Contract drawings need not be re-issued unless a major change that cannot be described by a change notice containing a sketch or description is involved.

c. Periodic Site Visits

The design service project engineers should make periodic vists (once or twice monthly) to the site to provide continuing liaison between the design office and the field office. In addition, site visits should be made when the resident engineer requests a specific consultation or advice. A brief record of site visits should be maintained by the designer.

d. As-built Drawings

As-built drawings should be prepared after completion of the work. In doing so, marked drawings furnished by the resident engineer, field and design change notices, and corrections showing "conformed" sets of drawings in the design office should be used.

e. Changes to Design Criteria

Revisions to contract drawings and specifications may be necessitated by changes in design criteria, design policies, agency requirements, right-of-way negotiations, and field conditions. This work is considered within the designer's scope of services unless the changes are significant and additional design service monies are approved. Every effort should be made to identify changes on the change notice using sketches or new details rather than to issue revised contract drawings.

D. HUMAN RESOURCES AND LABOR RELATIONS POLICY

The management program for human resources and labor relations policy should be divided into two phases--preconstruction and construction. The principal objective of each phase is to obtain and retain all levels of efficient personnel under a coordinated planned administrative procedure of recruitment, selection, and utilization of human resources.

An effective program requires that all existing productive or counterproductive conditions be carefully weighed and provides for action to be taken to overcome counterproductive conditions and to monitor productive conditions to maintain or improve their advantages. Examples of counterproductive conditions might be a shortage of available skilled craftsmen, housing shortages, or lack of transportation. Examples of productive conditions might be the existence of successful area training programs or a cooperative management labor productivity campaign (e.g., the PRIDE program in St. Louis, Missouri, and the Union Jack program in Denver, Colorado).

1. Preconstruction Phase

a. Regulations

During the preconstruction phase, federal, state, and local regulations should be given attention. The project management plan should require that the owner's contracting agency be responsible for obtaining the required issuances of wage predeterminations and notifications relating to labor relations and human resources. The following are suggested guidelines but are not necessarily all inclusive:

- Appropriate and definitive wages and classifications from the Department of Labor
- Appropriate reference to work hour provisions
- Notices required to be posted under the Fair Labor Standards Act
- Notices required to be posted under the Civil Rights Act
- Equal Employment Opportunity II Affirmative Action Plan postings

- Suggested nondiscrimination forms for use with recruiting sources
- Required Occupational Safety and Health Administration postings
- Notices concerning time off for voting
- Applicable Presidential executive orders and directives.

Even though many of the above items appear in federal and state contracts, a new authority created to administer an urban construction program often is not familiar with all these requirements. Referring to them in broad proposal terms or leaving them to the execution contractors often results in confusion, noncompliance, and other negative impacts that are counterproductive if they occur during the construction phase of the project.

b. Area Awareness Studies

The project management plan should require management area awareness studies because many area conditions will have an impact on the project. An awareness of these conditions permits action plans to be developed to lessen the negative impacts and maximize the positive impacts. All too often urban projects suffer costly manpower, housing, transportation, safety, and public relations surprises because an awareness study was not made before construction started. Often an overall demographic evaluation of the area will provide the breakdown of population by ethnic groups (EEO value) and by age and sex groups (workforce value). Among the subjects to be included in awareness studies are:

- Geographical area of manpower supply
- Current and projected manpower availability by skill level
- Transportation facilities and traffic peak periods
- Availability and cost of worker housing
- Projects in the area that will compete for manpower
- Routing and safety of pedestrian traffic during construction
- Parking for workers
- Available lunchroom facilities
- Skill development and training centers
- Manpower sources
- Recreational facilities.

Although this list is not all inclusive, these studies are vital to the cost value of a project. They provide base information that can be updated during construction and can contribute to controlling overtime, maintaining a more balanced workforce, and more readily meeting scheduled completion.

c. Labor Relations

Certain labor relations decisions must be made before construction begins. The most notable of these is whether the negotiation of a project agreement is desirable or whether the issue of union versus

open shop can or should be left to the discretion of each execution contractor. The project management plan should require an in-depth study to determine past and current labor relations practices in the area. Such a study should address the strength of the local labor organizations, history of past performance, productivity, strikes, and collective bargaining organizations and their effectiveness.

d. Policy Decision

Following the collection of labor relations data and its correlation with other elements of the management plan, a labor relations policy decision should be made. It is suggested that the following factors be considered in reaching that decision:

- Project Agreement--In a strong union labor market with a history of frequent strikes or with weak building trades leadership, a project agreement backed by the international unions might be considered. The project agreement may be the best approach if the nature of the project is such that much of the work is new to the area. It also is a valuable coordinating tool when many contractors will be involved in the construction phase.
- Local Agreements--Reliance on local agreements is an approach that works best if all the local agreements expire at approximately the same time or, better still, have a duration extending beyond the life of the project. The history of local union relationships should be well established as being friendly and cooperative and devoid of stoppages and strikes. Local union leadership should be strong, trustworthy, and politically secure.
- Combination of Open Shop and Union Shop--This combination rarely works when the general contractor has a union shop and the subcontractors have an open shop. It works better when the general contractor has an open shop and the subcontractors union shops. In most U.S. cities (with the exception of some selected geographical areas), this approach on a major urban project would not be trouble-free; the area awareness study mentioned above would provide valuable information for use in making this decision.
- Open Shop--The open shop policy would be limited to selected geographical areas for urban projects and an area awareness study would provide valuable information.

e. Legislation

Labor legislation that might have an impact on an urban project should receive attention during both the preconstruction and the construction phases. Federal, state, or local legislation dealing with labor relations could be beneficial or harmful to the project. Labor legislation should receive constant attention in the planning

process. Examples of sensitive legislation are right-to-work laws, common situs picketing, Labor Peace Act amendments, Taft-Hartley Act amendments, and amendments to wage and hour laws.

2. Construction Phase

By considering the factors identified above during the preconstruction phase, a comprehensive program can be developed for the construction phase. If this process is followed, labor relations can be expanded to an industrial relations concept at the construction phase. Industrial relations in the construction phase can be either a loose network or a controlled-managed network.

a. Loose Network Alternative

Under the loose network alternative, the execution contractors function independently of one another during the preconstruction phase. If one or more neglects his human resource relations responsibilities or fails to act appropriately, the essential human resource factors can become critical and cause the whole project to have a negative image. It also can result in conflicting contradictory actions, such as improper job assignments, unnecessary manning of specific portions of the project, and problems of a similar nonproductive and costly nature.

b. Controlled-managed Alternative

The controlled-managed alternative is more desirable. Its purpose is to coordinate industrial relations functions at a single level so that positive remedial and preventative actions will occur at all performance levels. All the data and information gathered during the preconstruction phase are available as needed during the construction phase. Each execution contractor is supplied with the same posting regulations and bulletins. Uniformity of compliance is achieved throughout the project and omissions and errors of commission can be avoided. An overall image of human resource efficiency is developed throughout the project and this is conducive to productivity. Area awareness background information as well as current updates are available to permit problem areas to be identified as early as possible, and with such identification projectwide action programs can be launched to provide solutions. Coordination between execution contractors is possible; therefore, absenteeism and turnover can be dealt with on a project level, thus preventing unnecessary overtime and schedule extensions. Administration of manpower and labor relations policies can be coordinated to maintain an uninterrupted work flow. Labor relations and human resource management planning accomplishes these objectives with a comprehensive plan developed during the preconstruction phase and implemented during the construction phase. Implementation calls for regular meetings with all execution contractors during construction.

E. RISK MANAGEMENT

Too often the sequential approach in project planning does not provide for sufficiently early consideration of risk management (insurance) and, hence, the insurance industry's contribution to the project's early stages is lost even though most large projects have a large volume and variety of risks (hazards). Every risk should be identified and its full consequences assessed before plans are finalized to reduce the chance of some risks being overlooked and, even more important, to permit residual risks (those risks identified but neither avoidable, controllable, nor insurable) to be quantified.

A team of the owner's staff members or consultants must be formed early to provide a multidisciplinary overview of the project and its elements and to determine how risks affect the technical, legal, political, social, and financial segments of the project from beginning to completion. Risk control--prevention of the happening or insurance with a risk taker--involves an economic decision that should be given high priority in project planning. It must be remembered that risk problems are not solved only by insuring; if the risk is unclear, the insurance may be worthless or costly in relation to the benefit. A risk management program should consider the elements discussed below.

1. Risk Identification

Risk can be defined in terms of the event (what may occur to the detriment of the project), its probability (how likely is the event to occur), and the amount involved (dollars of maximum possible loss or number of losses that could occur). Risk can be explicit or precise, implicit or vague, direct or consequential.

Residual risk is the amount of risk that remains after all steps have been taken to eliminate it. A loss is a loss regardless of who bears it--owner, contractor, financier, or public--and it costs money and results in delays. The larger the risk, the more it needs to be considered, but many large risks are not apparent, at least in terms of magnitude. Risk management implies control of events, which can be misleading; in fact, it means responding to events in advance or as they occur.

Risk can be classified further in terms of catastrophic, customary, and indirect risk as well as in terms of insurance risk categories. The classifications are defined and examples of the various risk classifications and categories are given in Table 1.

2. Risk Control

The risk management program should provide for the analysis and assessment of risks to determine the maximum protection and funding

TABLE 1. RISK CLASSIFICATION AND CATEGORIZATION

Classification	Examples of Risk Type	Insurance Risk Category
Catastrophic Risks		
Are massive and have direct impact; can cause greater losses than insurance industry's capacity to cover; essential to consult with insurance industry early in design and planning stage; extent difficult to determine.	Earthquake, landslide or collapse, flood, explosion, design failure, civil disturbance	Property and casualty
	Prime contractor failure	Bonding
	War, terrorist attack, social/environment	None
Customary Risk		
Not catastrophic but can cause large financial loss; most always are insurable but economic value of insurance must be measured.	Project works (unfinished or complete), equipment and materials, employee injuries, third-party injury or damage, project delay	Property and casualty
	Subcontractor and major supplier faliure	Bonding
	Exchange fluctuation	Political
Indirect Risk		
Losses to a project that may result from domino effect; require intensive analysis to identify and often can be an accumulation of risk; cost of control must be measured against possible loss to project; cause of loss often can be a small subcontractor.	Nonavailability of key components; fire, etc., at key component manufacturer; loss of key component in transit	Property and casualty
	Insolvency of key component manufacturer of supplier	Bonding
	New legislation	Political

required. Particular attention should be given to activities on or near the project's critical path through an assessment of risks of delay and alternatives available to mitigate the consequences.

Losses that can occur should be evaluated and available contingencies identified. The program should provide for an audit in which parameters are rechecked constantly. The project overview by the risk management group must be ongoing, multidisciplinary, and include every significant part of the project. The following should be considered:

- Risk Evaluation--Considering the design contemplated, the cost of alternatives, the contractors' capabilities, the type of contracts (e.g., turnkey or separate jobs), supply prebuying as a feasible alternative, contractural wording (e.g., war- ranty, indemnification), the basis for considering competitive bids, how well the project will be managed and controlled, contingency plans for emergencies, the financial security of contractors participating and alternatives in the event of default, and the extent to which any one risk can affect the entire project.
- Risk Assessment--Involving constant identification and quantification of uncertainty, nature of risk, and the total amount of potential direct and consequential losses and precise definition of internal and external events.
- Risk Analysis--Involving the analysis of risks to determine if they are avoidable or unavoidable. Avoidable risks should be avoided if it is economically feasible to do so. Unavoidable risks should be analysed to determine whether they are insurable at rates that are cost-effective. Uninsurable risks should be analyzed to determine whether they are controllable and whether control measures should be taken. Uncontrollable risks represent the amount of residual risk that must be planned for, minimized, and ideally funded.
- Loss Prevention--Involving established procedures for providing an organization that will ensure the adequacy of supervision, first aid and medical facilities, rehabilitation, and record-keeping; emergency systems and contingency plans; plan review, site inspection, and compliance with standards and insurance company requirements to minimize property loss; identification of loss potential from bodily injury and property damage caused by unsafe work procedures and hazards and corrective action to be taken; physical security (loss prevention) through plan review, site inspection, review of transit, site-storage, and material handling risks, and security systems; and an on-going audit of the program.

3. Insurance Protection

The concept of insurance protection should be considered carefully and established early in the planning and development stage of the project. It should, as closely as possible, approach fully funded self-insurance. This area of management requires expert knowledge,

and unless a staff of such a caliber is already employed, outside consultants should be hired to design and implement a program and be employed until staff is hired and experienced enough to assume such responsibilities. Although cost-effectiveness should be the paramount goal of any program, the means of achieving this goal require careful analysis.

Basically, there are two major approaches to arranging an insurance program to cover major construction projects. With the so-called conventional approach, each contractor and subcontractor arranges a separate program of insurance coupled with owner specifications. Such an approach with a high-cost item like insurance may not be cost-effective for any of the following reasons:

- Lack of economy in volume purchase.
- Lack of financial security (stability) of marginal contractors.
- Specifications that are the minimum necessary to protect the owner.
- The difficulty of administering many individual policies with varying limits of liability subject to different terms and expiration dates.
- Redundant charges by contractors (e.g., general and administrative overhead and profit).
- Project delay from cross litigation by various insurance companies over claim payments.
- Contractor delay or failure to collect claims from substandard insurance companies (the owner may be required to make dollar advances to keep contractors solvent).
- The disjointed, many-faceted approach to life safety and loss-control arising from the multiplicity of insurance companies involved for each contractor.

The alternative to conventional insurance is an owner-designed and -controlled program known as a coordinated insurance program (CIP) or "wrap-up" insurance. CIP is controversial and subject to constant debate but it can be cost-effective. The advantages of an owner-controlled program are that:

- The owner, not the contractor, negotiates policy terms and costs, eliminating redundant charges for expense and profit items.
- The administrative burden of maintaining records on contractor compliance with contract specifications for insurance is eliminated. (All contractors have the same coverage, limits, and expiration dates of policies.)
- The safety and loss control programs are uniform.
- Cross litigation is eliminated.
- Claim handling is uniform.
- Small and minority contractor participation in the project is not excluded because insurance is available.
- Insurance costs are confined solely to the project through self-rating.
- Cash flow advantages become available to the owner.

The disadvantages of an owner-controlled program might be that:

- Insurance costs are highlighted in one big package.
- The owner's staff may not be adequately trained or readily available to handle a program.
- The contractor should be fully responsible for all costs related to his performance.
- The contractor may be better able to manage his own insurance and safety programs (he takes the consequences if he is wrong and relieves the owner of this burden).
- Management of the risk management program is costly.
- Insurance costs are not subject to as many competitive forces.

The types of insurance usually placed in an owner-controlled program are workers' compensation, comprehensive general liability including products and completed operations, railroad protective liability, and builders risk. This coverage applies to the owner and all contractors involved in the project, with the exception of hauling contractors (unless activities are exclusive to the project) and supply contractors. Surety bonds are the responsibility of each individual contractor; however, when an owner-controlled program exists, it is possible to develop a small and minority-contractor surety bond program with insurance companies to enhance the probability of participation by these contractors.

F. DISPUTE RESOLUTION

It is in the best interest of all parties to effect timely resolution of disputes. In general, disputes should be resolved at the lowest administrative level possible. Procedures for dispute resolution should be defined clearly. For those disputes that cannot be resolved through administrative procedures, consideration should be given to such dispute resolution procedures as litigation, mediation, arbitration, an independent board of consultants, and a contract appeals board. Incentives to speed dispute resolution should be considered; these include payment of interest at a rate exceeding the losing party's normal borrowing rate and reimbursement of the winning party's claim preparation and defense costs and attorney's fees.

When a dispute arises, the owner should require the claimant to set forth the nature of the dispute and the relief sought in writing, in a timely fashion, and in sufficient detail so that it will be understood by the responsible person at the management level. The claimant is entitled to a timely response, in writing, clearly setting forth the basis of the owner's position. Management procedures should be initiated to provide for the review and moniting of pending disputes and to reduce the risk that disputes will escalate and positions will harden because of inattention, unreasonableness, or personality problems between the claimant and owner's representative.

Disputes can be avoided if contingencies are dealt with in the framework of contract documents. The recognition of contract elements that are vulnerable to change and misinterpretation can help stem disagreements. Clauses dealing clearly with changed conditions and quantity variations should be included in the contract document. In general, disclaimers and exculpatory language should be omitted.

The selection of formal dispute resolution procedures should be a function of project size and the owner's resources. A brief description of the various dispute resolution procedures and their advantages and disadvantages is provided below.

1. Litigation

Litigation in the local courts of general jurisdiction is the traditional method of dispute resolution. In some cases, a jury may be demanded as a matter of right. Judges generally are not specialists since construction cases are relatively few in number as compared with criminal, domestic relations, negligence, and general commercial cases. Litigation in the local courts of general jurisdiction deprives the parties of the opportunity to have the facts evaluated by an individual with independent expertise in the complex technology at issue; however, it offers procedural safeguards, such as pretrial disclosure and the right of appeal, generally not available in other dispute resolution procedures. Generally, this procedure is the most time-consuming and expensive and the least desirable approach.

2. Mediation

A mediator generally is selected by the involved parties after a dispute has arisen. His function is to provide an atmosphere in which the parties themselves can resolve the dispute. He may make recommendations for settlement, but his recommendations are not binding on the parties. Mediation offers informality and the good offices of an independent third party. It lacks finality and may prolong the time required for ultimate resolution because the mediator's recommendations are not binding.

3. Arbitration

Arbitrators (one or more) generally are appointed after a dispute has arisen. The method of their appointment and conduct of the hearings is governed by contract, which may incorporate the rules of the American Arbitration Association, and by applicable statutes. The decision of the arbitrators generally is final and binding on the parties and not subject to appeal. The advantages of arbitration are the independent expertise and impartiality of the arbitrators. Under the law in most states there is no right of pretrial disclosure, arbitrators are not bound by rules of law,

and there is no right of appeal on the merits, only for substantial procedural deficiencies. Arbitrators often will not sit continuously and it may take years to resolve complex disputes requiring numerous hearings. Some states still do not have enabling legislation that recognizes arbitration and provides a means of enforcing arbitration awards, which renders arbitration an impracticable means of dispute resolution in those states.

A variation of arbitration is mediation-arbitration (MED-ARB). In this process an independent panel functions as a mediator, and if mediation is not successful, the panel functions as an arbitrator.

4. Board of Contract Appeals

The various boards of contract appeals of the federal departments serve as models for this procedure. Governed by the Administrative Procedures Act, board members generally are appointed from the ranks of department employees and are given sufficiently independent status to promote impartiality. Their decisions generally are final and binding concerning questions of fact and are subject to appeal concering questions of law. An in-house board of contract appeals gives the owner greater control over the dispute resolution process. However, there is the ever present risk that institutional bias will impare impartiality, and it is costly to maintain a staff of competent persons to serve as full-time board members or to be diverted from their normal responsibilities for a sufficient time to hear and determine disputes.

5. Independent Board of Consultants

This is a relatively new method. The board is selected by the parties when entering into the contract. It meets periodically as the work proceeds to review progress and incipient problems. The board is intended to have a prophylactic effect and to prevent major disputes from arising. The board may serve as an arbitrator or only a mediator, as set forth in the contract documents. Establishing an independent board of consultants with ongoing responsibility through the life of a project is an innovative means of dispute avoidance and resolution. Cost considerations may make it practical for use only for very large projects.

G. PROCUREMENT

1. Contractor Selection and Types of Contract

The two primary methods for selecting potential contractors to provide services, materials, and equipment are through advertised, competitive-bid contracts and through negotiated contracts. State and local laws, however, may impose requirements that constrain the owner. Competitive bidding is better suited to lump sum and unit-price contracts than to cost-reimbursible contracts.

A brief description of the types of contracts that may be considered is presented in the following excerpt from a paper delivered by Solomon Ribakoff at the January 1979 ASCE Conference on Construction Risks and Liability Sharing, Scotsdale, Arizona:

A. BASIC CONSIDERATIONS AFFECTING SELECTION OF CONSTRUCTION CONTRACT TYPES

The enormous scale and complexity of construction projects in the United States, both in the public and private sectors, coupled with the fact that both public and private owners are too often unwilling or unable to wait for finished design before commencing construction, and the further fact that there is an ever-growing increase in statutory and regulatory controls upon the employment and use of labor, equipment and materials, all result in the need to utilize a wide variety of construction contract types. In considering the various types available, it must be remembered that the owner of any construction project has three goals: most economical cost, specified quality, and completion on schedule. These goals are not equally attainable in any one contract, however, with the result that the owner must compromise among them to achieve, in the greatest degree, those that are the most important to him. The following types of contracts vary in their effectiveness in achieving one or two of the three goals. Some orderly arrangement of these contract types is necessary, to provide a ready means of comparison, and listing them according to the degree that a contractor is required to assume responsibility for the cost of performing the contract seems to be the most logical. A Defense Acquisition Regulation (DAR 3-401 (a)) speaks to such an arrangement, thus:

"At one end is the firm fixed-price contract under which the parties agree that the contractor assumes full cost responsibility. At the other end of this range is the cost-plus-a-fixed-fee contract where profit, rather than price, is fixed and the contractor's cost responsibility is therefore minimal. In between are the various incentive contracts which provide for varying degrees of contractor cost responsibility, depending upon the degree of uncertainty involved in contract performance."

Accordingly, the descriptions and discussions of contract types which follow are arranged in the order of decreasing responsibility upon the contractor for costs of performance.

B. FIXED-PRICE CONTRACT TYPES

1. In General

The fixed-price type of contract provides for performance of specified work in consideration of a stated price (or a number of stated unit prices) which are not subject to any adjustment except as specifically provided therein. Variations in this type of contract are hereinbelow described, including the advantages and disadvantages inherent in each.

The basic difference between a fixed-price type of contract and a cost-reimbursable type is that the contractor is, essentially, in the former type obligated to accept the risks of uncertainties while in the latter type the owner is, essentially, so obligated. Accordingly, in the fixed-price type the firm bid price submitted by the contractor will--certainly should--include contingencies for unknown conditions or circumstances which the contractor feels may arise during construction, and as to which the owner has not agreed to assume responsibility.

The amount of contingency which a contractor includes in a bid for work under a fixed-price type depends on (1) his experience on similar projects, (2) his present workload, (3) his familiarity with the project, (4) how definable the parameters of construction are, (5) the nature and possible extent of the risks and the extent to which these have been defined and allocated as between the owner and the contractor in the contract documents, and (6) the degree of risk which the contractor is willing to accept.

2. Lump-Sum, Firm-Fixed-Price Contract

(a) Description

The firm-fixed-price type of contract provides for a price which is not subject to any adjustment by reason of the cost experience of the contractor in the performance of the contract. When used under the proper circumstances, it places maximum risk upon the contractor. In general it is awarded on the basis of formal advertisement for sealed bids, but may, in exceptional cases, be awarded on the basis of negotiations after the receipt of proposals.

(b) Application

An advantage to the owner is that it (1) places maximum risk upon the contractor; (2) because the contractor assumes full responsibility in the form of profits or losses for all costs under or over the firm fixed price, he has a maximum profit incentive for effective cost control and contract performance; (3) both secure an advantage from the fact that the use of this type of contract imposes a minimum administrative burden on each, with an exception hereinbelow discussed.

(c) Advantages

(1) The total time required from project conception to completion is the longest of any type contract, because time must be taken to prepare complete plans and specifications, and to receive and evaluate bids before any contract can be awarded.

(2) It is a firm-fixed-price contract only if the end product desired by the owner is known and specified in complete detail in the contract as awarded. If the owner's desires are not firmly fixed at contract award, then during the progress of the contract there will be numerous, costly changes. The guaranteed cost that the owner thought he had becomes an illusion.

(3) If the owner imposes, or attempts to impose, all significant risks on the contractor and takes none for himself, the contractor, in his bid price, must necessarily provide ample allowance for at least those risks which pose the greatest hazard of additional cost. Ordinarily the contractor will not include in his bid sufficient allowance for every significant risk, since doing so will undoubtedly make him noncompetitive. If every such risk does occur, the contractor may lose a great deal of money on the job. This motivates the contractor to seek claims to assert against the owner to reduce the loss. On the other hand, if none or few of the risks for which the contractor has provided in his bid occur, the contractor may make a great deal of money. This makes for a happy contractor, but the owner is paying too much for what he receives.

(4) The firm-fixed-price contract provides no financial motivation to the contractor to perform work of a higher quality than that which just meets the contract specifications.

(5) If the work to be done is of such a nature that little competition can be obtained in the bidding process, there is no guarantee that the firm-fixed-price actually represents a fair and reasonable price for the work.

(6) If modification to the design and field changes become necessary or desirable, lengthy change order negotiations and contract revisions are likely to occur, with consequent promotion of an adversary relationship. At the least, the flexibility of the engineer, during construction, to introduce logical modifications is impaired.

3. Fixed-Price Contract with Escalation

(a) Description

This type provides for upward and downward revision of a stated contract price upon the occurence of certain contingencies which are specifically defined in the contract. The risks are reduced by the inclusion of escalation provisions in which the parties agree to revise the stated price upon the happening of a prescribed contingency. Where escalation is agreed upon, upward adjustments may be limited by the establishment of a reasonable ceiling, and provisions may be included for downward adjustments in those instances where the prices or rates fall below the base levels provided in the contract. Generally, escalation provisions are of two broad types: (1) price escalation provides for adjustment of the contract price on the basis of increases or decreases from an agreed upon level. (2) Labor and material escalation provides for adjustment of the contract price on the basis of increases or decreases from agreed standards or indices in wage rates, specific material costs, or both.

(b) Application

The use of this type is appropriate where serious doubt exists as to the stability of market and labor conditions which will exist as, for example, during an extended period of construction and where contingencies which would otherwise be included in a firm-fixed-price contract are identifiable and can be covered separately by escalation. Obviously, labor and material escalation should be limited to contingencies beyond the normal control of the contractor.

(c) Advantages

As to projects of long duration, say, in excess of 18 months, and since inflationary effect on the costs of labor, equipment and materials is a definite factor which must be considered in pricing such jobs, contractors must either include a contingency amount covering the hazard as to the extent of such cost increases, or refuse to bid the job. In the former case the contract can become a gambling transaction; in the latter the owner loses the benefit of competition for the job.

(d) Disadvantages

(1) Since the owner accepts at least a substantial part of cost increases due to inflationary effect, he no longer has a true firm-fixed-price commitment as to the job.

(2) There are obvious difficulties inherent in its administration.

4. Unit-Price Contract

(a) Description

This is a fixed-price type contract with a number of stated unit prices for component elements of the work, such as per cubic yard of concrete, per ton of steel, per cubic yard of earth excavation, etc. The design must be sufficiently complete that the nature of the work required for each unit price item and the total number of units of each item can be ascertained with reasonable accuracy. Bids can be compared by totalling the extensions of the unit price bid for each item and the estimated quantity of each item.

(b) Application

The use of this type is appropriate where the total quantity of work cannot be accurately calculated at the time the contract is negotiated, where the owner has the general design but has not completed the detailed design at the time the contract is negotiated, or where the owner contemplates design changes.

(c) Advantages

The owner only pays for the actual quantity of work performed. Design changes can be effected without lengthy negotiations or complicated cost keeping systems.

(d) Disadvantages

(1) Subdividing the work into a sufficient number of distinct items is a complex process. Too many items are difficult to administer. Too few items create problems when design changes are made. For example, concrete for thin walls is more costly per unit than concrete for massive abutments, so that in most instances a single unit price for concrete work would be inappropriate. The difficulty is in determining how many separate concrete items to define.

(2) The contractor's fixed costs for each item must be spread over the estimated quantity in arriving at a unit price. Significant variations between estimated and actual quantities can result either in a windfall profit or a substantial loss. To mitigate this problem, variation-in-quantity clauses (providing for price adjustment in the event of defined quantity variations) or split quantities (one unit price for a specified minimum quantity in which the contractor is instructed to include all fixed costs and a second unit price for the total quantity in excess of the specified minimum quantity) are utilized.

(3) Disputes frequently arise as to the applicability of unit prices to changed work; e.g., that the work required by a particular change so modified the nature of performance as to render the unit price inapplicable to the changed work.

(4) The owner must engage an adequate staff to measure actual quantities of work.

(5) It has the disadvantages applicable to lump sum contracts set forth in section 2(d) above.

5. Unit-Price Contract with Escalation

(a) Description

As stated in section 3(a) above.

(b) Application

As stated in section 3(b) above.

(c) Advantages

As stated in section 3(c) above.

(d) Disadvantages

As stated in section 3(d) above.

C. COST-REIMBURSABLE CONTRACT TYPES

1. In General

The cost-reimbursement type may be described, in general, as one which provides for payment to the contractor of allowable costs incurred in its performance and to the extent prescribed therein. This type of contract establishes an estimated total cost and a ceiling which the contractor may not exceed (except at his own risk), without prior approval or subsequent ratification by the owner or his engineer. It is most suitable for use when the uncertainties involved in contract performance are of such magnitude that the cost of performance cannot be estimated with sufficient reasonableness to permit the use of any type of fixed-price contract. In addition, it is essential that the contractor's cost accounting system be adequate for the determination of costs applicable to the contract and that appropriate surveillance can be accomplished by the personnel of the owner or engineer during performance so as to give reasonable assurance that inefficient or wasteful methods are not being used.

2. Cost-Plus-Incentive-Fee Contract

(a) Description

In this type of contract, the owner and contractor, before award, negotiate the following items:

Target cost
Target fee
Minimum and maximum fee
Fee admustment formula

The formula determines the amount of fee payable to the contractor on the basis of the relationship between the negotiated target cost and the final total allowable costs. After the work is completed, the contractor and the owner negotiate the final fee (but not the final contract costs), in accordance with the fee adjustment formula. The formula might provide, for example, that the contractor would be penalized 25 percent of the actual cost overruns above the target estimate and rewarded by 25 percent of the underruns--in both cases, subject to the previously agreed minimum and maximum fee. Such a contract can also have separate incentive provisions for early completion.

(b) Application

As stated in section C. 1. above.

(c) Advantages

(1) It permits the contractor to get started while engineering design is in progress, thus promoting earlier completion.

(2) It permits provision of greater profit motivation to the contractor than exists in other cost-reimbursable type contracts.

(3) The owner does not pay, by way of a contingency otherwise included in the bid price, for risks which do not materialize.

(4) Considerable incentive to reduce costs can be "built in" by providing for adequate profit increase to the contractor.

(d) Disadvantages

(1) The owner has no guaranteed maximum of what the job will cost. (Although, if the design is sufficiently complete at the time the contract is let, the owner and contractor can negotiate a maximum guaranteed cost.)

(2) The negotiation process requires that agreement be reached as to several difficult matters.

(3) It has the other disadvantages generally applicable to cost-reimbursable type contracts, described in section C. 1. above.

3. Cost-Plus-Award-Fee Contract

(a) Description

In the cost-plus-award-fee type of contract the contractor is paid for his efforts as follows:

(1) He is reimbursed by the owner for his actual allowable costs in performing the contract.

(2) He is paid a base fee, negotiated prior to contract award, which does not vary regardless of the performance level he achieves, and which is a low percentage of the agreed estimated total cost of the work, and

(3) He is given the opportunity to earn, through superior performance, an additional award fee, which may be two or three times the amount of the base fee.

The amount of the award fee that the contractor earns in a given period is determined unilaterally by the owner, based on the owner's evaluation of the contractor's performance during that period. The basis on which the owner will make his evaluation is set forth in the contract and is designed to focus the contractor's emphasis on achieving the goals that the owner considers most important. The opportunity to earn the award fee provides the strongest possible profit motivation to the contractor to improve his performance in the areas designated by the owner.

The contract itself will describe the factors, and the weights assigned to them, that the owner will use in his periodic evaluation of the contractor's performance. Periodically, if the owner's goals change, the contract, by mutual agreement, may be amended to revise the weights assigned to the various evaluation factors or to add new factors.

The number of factors to be used in performance evaluation can be few or many. It is generally desirable to limit them to as few as possible, in order that the contractor's efforts to achieve them may not be unduly fragmented.

In an average construction program, an appropriate list of evaluation factors might be as follows:

Control and reduction of costs	40 percent
Quality of construction	20 percent
Maintenance of schedules	40 percent

During the progress of the work, the contractor is paid only the base fee each month when that month's portion of the work is completed. Periodically--perhaps every 6 months--the owner's designated representatives evaluate the contractor's performance for that period and give him a numerical grade for his overall performance in the factors set forth in the contract. This overall grade determines the portion of the maximum attainable award fee that the contractor has earned and will be paid for the period being graded. The owner's determination is unilateral and not subject to appeal by the contractor, although he is given the opportunity to discuss with the owner the grading he received, and to learn where and in what way he may not be meeting the owner's expectations.

(b) Advantages

It fosters close communication and cooperation between the contractor and the owner. Both are attempting to accomplish the same ends rather than working at cross purposes or, at least, working without motivation for close communication and cooperation, as is often the case in other contractual types.

(c) Disadvantages

(1) Lack of a guaranteed cost to the owner.

(2) Since the amount of the award fee paid to the contractor is determined unilaterally by the owner, personalities may improperly affect the amount of the award.

(3) Agreement on estimated total cost of the work may be difficult to reach. This figure is important both with respect to the base fee and evaluation of performance in determining the amount of award fee.

(4) The disadvantages which are inherent in all cost-reimbursable type contracts, section C. 1., above.

4. Cost-Plus-A-Fixed-Fee Contract

(a) Description

The cost-plus-a-fixed-fee contract is a cost-reimbursable type which provides that the contractor shall be reimbursed for all allowable costs and, in addition, paid a fee that is fixed. The fixed fee, once negotiated, does not vary with actual costs but may be adjusted as a result of subsequent changes in the work or services to be performed under the contract, certainly in the event of a change or changes which amount to change of scope.

(b) Application

The cost-plus-a-fixed-fee contract is suitable for use when, and only when, it is not feasible to use a fixed-price type of contract, i.e., when, as perviously stated, the uncertainties involved in contract performance are of such magnitude that the cost of performance cannot be estimated with sufficient reasonableness to permit the use of any type of fixed price contract.

(c) Advantages

Fewer areas of potential disagreement to resolve than with respect to the cost-reimbursable types above described.

(d) Disadvantages

(1) There is little or nc incentive to the contractor, other than his pride, to perform at the most economical cost to the owner.

(2) A good estimate as to the total construction costs is essential; otherwise the amount of the fee, which is predicted upon the amount of such estimate, among other factors, may be unfair to the owner or to the contractor.

(3) Disadvantages inherent in all cost-reimbursable type contracts, section C. 1. above.

5. Cost-Plus-Percentage-of-Cost Contract

(a) Description

In the cost-plus-a-percentage-of-cost contract the contractor is paid his actual costs plus a percentage of those costs as his profit. This type is prohibited by law for use in U.S. government contracting.

(b) Application

Appropriate for use where the owner needs to save the maximum amount of time in getting construction started; cannot provide detailed plans and specifications due to lack of information as to exactly what needs to be constructed or reconstructed; e.g., repair of damages due to earthquake effect, or in any event his plans and specifications are inadequate to permit the use of any of the contracts above described; and the owner knows with whom he is contracting; i.e., is dealing with a contractor with whom he has previously had excellent experience as to performance and management integrity.

(c) Advantages

Permits the job to get started in the minimum amount of time as compared with all other types of contracts.

(d) Disadvantages

(1) The higher the costs, the greater the contractor's profit. The contractual incentive is to spend, not save, money.

(2) Same disadvantages as inherent in all other cost-reimbursable type contracts, section C. 1., above; also that the cost exposure of the owner is greatest in this type of contract.

2. Work Packaging

It must be decided whether to procure the services of general consultants or contractors or multiple (specialty) consultants or contractors to execute design and construction. This decision will depend on the availability of competent, experienced in-house staff or use of a construction project management consultant to coordinate the design and construction activities and the relative cost.

The fewer the number of individual contracts, the fewer will be the problems of administration and coordination. Larger contracts may attract bids from contractors outside the immediate geographical area and enhance competition; however, they also may reduce competition by effectively precluding participation by smaller local contractors due to problems of availability of insurance, bonding, and financing. Larger contracts also may thwart the implementation of social goals, such as minority business enterprise (MBE) participation. Insurance and bonding problems may be overcome by the use of a coordinated (wrap-up) insurance program.

3. Project Management Services

A project management support consultant (sometimes referred to as construction manager) can assist the owner by coordinating project planning, design, and construction under a professional services agreement. Owners can use this method in various ways and the services can include total project management or only limited areas of management's tasks determined by the agreement. In order to be effective, the project management consultant should be involved during the design phase so that he can monitor the emerging design to ensure that the proposed construction is possible within the budgeted time and cost. Depending on the owner's needs, project management consultant services can include predesign, programming, budgeting, cost analysis, and value engineering; scheduling; guidance on materials and construction methods; recommendations regarding the way in which the construction package generally should determine the plan of construction; labor relations; and management of the bidding, negotiation, and contract award process.

Although this method has been used widely (particularly on large and complicated projects lasting several years), there has been a lack of uniformity in the way it is applied and in related terminology. This prompted the Subcommittee on Methodologies and Administration of American Society of Civil Engineers' (ASCE) Construction Division to undertake a study of professional construction management. The Subcommittee found that:

A number of problems became apparent. . . .The most outstanding were: (1) wide variations in the responsibilities assigned to the Professional Construction Manager (CM); (2) the wide variety of work actually performed by the CM; (3) the lack of an agenda of pertinent items of responsibilities and work that should logically be assigned to the CM; (4) the lack of an acceptable delineation between the CM and the general contractor functions; (5) the lack of accepted definition of a CM; (6) the need for definitions of many words and phrases used in CM terminology; and (7) it would appear that the current excellent AIA document B 801 and AGC document No. 8 standard forms of agreement approach the problem primarily from the standpoint of the architect and the general contractor rather than from the standpoint of the construction manager.

Because of the wide variations in the CM concept and the lack of a standard specification for CM services, the ASCE Construction Division's Committee on Professional Construction Management has prepared a specification for broad usage in CM agreements. . . .care has been exercised so that it might satisfy the need for a document of moderate length, yet be flexible enough for all requirements.

Portions of that agreement (i.e., cover sheet, check list, and table of contents) are reproduced below for information purposes.

COVER SHEET

It is contemplated that an Agreement shall be entered into by the Owner and the Construction Manager (CM) which shall refer to this Specification for the responsibilities, authorities and scope of services to be provided by the Owner and the Construction Manager. In addition to this Specification, a check list and proposed detail for inclusion in the Agreement is shown below.

A proposed detailed form of Agreement is not provided herein, in-as-much as form and content of agreements acceptable to the parties may vary widely. If a proprietary agreement form (or some standard form) is used which includes the items listed in the check list below and which is acceptable to both parties, a generally satisfactory Agreement should result.

Note that (construction) Contracts should contain supporting clauses whenever the CM is directly involved in quality control, Par II.3.23; expediting, Par II.3.22; determination of completion of Work, Par II.3.25 and II.3.40; and safety and Equal Employment Opportunity provisions, Par II.3.13.

CHECK LIST

Project description
Project estimated cost
Project desired completion date
Fees, costs, reimbursables and non-reimbursables
Payments, final payment
Insurance, liabilities
Assignments
Termination, suspension
Records to be kept, audits (See also II.3.8, II.3.11)
Laws under which the Agreement shall be interpreted
Personnel to be supplied by the CM
Expediting services, type, payment (If desired by Owner)
Quality control services, type, payment (If desired by Owner)
Arbitration as a tool for settling disagreements between the parties (If desired by the parties hereto)
Start up supervision (If desired by the Owner)
Substantial Completion--refer to I.1.19 which may require an addendum to provide for a more complete description for substantial completion.
Such other services as may be desired and which are not covered by this Specification.

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III.8 Be available for meetings
III.9 Promptly notify. . . .termination or suspension

4. Design Services

Decisions must be made concerning the extent of services to be contracted out and those to be performed by in-house staff, the use of a general engineering consultant, prime consultants contracting to the owner versus subcontracting to a general engineering consultant, and the scope of the contract packages. These decisions will be part of or result from decisions concerning organization and staffing, work breakdown structure, and overall management philosophy.

Selection of design services should be based on an analysis of the requirements of work to be performed and the qualifications of the firms. The general qualifications to be considered include:

- Reputation and standing of the firm and its principal members
- Experience and technical competence of the firm in performing comparable work
- Past record in performing work for government agencies and private industry, including performance from the standpoint of cost and the nature, extent, and effectiveness of the contractor's cost reduction program, quality of work, and ability to meet schedule (where applicable)
- Volume of past work in previous years and current workload
- Interest of company management in the project and the expected participation and contribution of top officials
- Adequacy of central or branch office facilities for the proposed work including availability of facilities for any special services that may be required
- Adequacy of the firm's accounting system
- Geographic location of the home office and familiarity with the locality in which the project is located
- Willingness to grant the owner principal or exclusive rights to any inventions that are developed for the project.

Personnel and organizational considerations include:

- Specific experience and qualifications of personnel proposed for assignment to the project including technical skills and abilities in planning, organizing, executing, and controlling; abilities in overall project coordination and management; and experience in working together as a team
- Proposed project organization, delegations of responsibility, and assignments of authority
- Availability of additional competent, regular employees to support the project and the depth and size of the organization (so that any necessary expansion or acceleration could be handled adequately)
- Experience and qualifications of proposed consultants and subcontractors

- Ability to assign an adequate number of qualified key personnel from its own organization, including a competent supervising representative.

5. Legal Services

The owner must consider the extent to which existing in-house legal staff will be utilized, a new in-house staff will be developed, or outside counsel will be retained. The principal criteria for deciding among these alternatives are cost, degree of specialization required, frequency and duration of need, and availability of talent. Many, if not all, of the following specialized legal services will be required:

- General corporate including bylaws, resolutions, and minutes of meetings
- Labor relations
- Legislative including legislation affecting grantee's powers and operations
- Bond counsel
- Condemnation and real estate
- Negligency (tort and third party suits)
- Contracts (drafting and negotiation)
- Contract dispute resolution.

6. Insurance Services

The following prospectus indicates the issues that should be considered regarding the insurance needs of a project, especially when a coordinated program under an insurance administrator (IA) is to be adopted. Selection of an IA should follow the negotiated contract format under which the potential IAs submit credentials and a party is selected, and the fee for services required is negotiated between the owner and the IA. This prospectus has been adapted for this report from the procedure used by a local transportation authority for its urban transit project.

The Board of Directors of the owner has adopted the concept of a coordinated insurance program that includes the owner's organization, its directors, officers and employees, all contractors, most subcontractors, and public agencies, utilities and other interests when associated with the owner in joint endeavors for the construction and operation of a _____ project.

Sealed proposals for the provision of all insurance required as well as certain administrative services will be received by the owner at any time. Proposals received after that time and date will not be opended. Individuals, firms or joint ventures submitting acceptable proposals will have an opportunity to appear before the owner upon request. Proposals must be prepared in substantial compliance with this prospectus and executed by an officer authorized to commit the firm(s).

The owner has not decided the types of insurance to be included in its coordinated insurance program. The owner will resolve this issue during the process of considering the various proposals. All proposals shall be submitted on the following assumed criteria:

1. All insurance administration shall be performed through an independent insurance service office entitled _____insurance administrators (hereinafter _____). Both the office and its identification shall belong irrevocably to the owner, and in the event of a change in insurance administrators, the successor would assume the established offices and title.

2. All insurance obtained for the owner shall be acquired net of commissions, including any profit sharing agreement or similar agreements, unless prohibited by law, in which case the owner shall be fully advised and the insurance administrators' fees shall be adjusted accordingly. It is contemplated that the insurance administrators shall be compensated on a fixed-fee-plus-reimbursable-cost basis with such fees and basis of cost to be negotiated. The proposal should not include any fees or basis of cost.

3. If workmen's compensation insurance is to be included in the program, coverage shall be provided through an insurer existing or established and duly admitted and licensed to write such coverage in the _____. The owner reserves the right to reject any proposed insurer.

4. The owner intends to procure a public liability limit of $____ million and a limit of $___ million for builders' risk insurance. Automobile liability and physical damage insurance is not to be included.

5. Administrators selected will be expected to design and acquire such policies of insurance and negotiate rates and coverage and submit proposals to the contracting officers of the owner.

6. Administrators will provide at least the following administrative services:
   a) Handle all correspondence and inquiries regarding the insurance program subject to such limits as the owner determines in its best interest.
   b) Prepare or review insurance specifications to be used in any contract as well as cross-insurance clauses for insertion in agreements executed by the owner.
   c) Prepare and deliver all policies and certificates issued to others (contractors insured under program, etc.).
   d) Maintain and review all insurance policies and certificates as well as those required to be provided by others.
   e) Maintain supervision over all insurance rating data including the rendering of actuarial services and submit such data on a timely basis to the contracting officer.
   f) Prepare all insurance manuals including loss and claim manuals and budgets of insurance costs.
   g) Provide a monthly review and evaluation of all claims and loss details with figures on all incurred losses and claims, such service to encompass casualty reserve analyses.
   h) Establish and coordinate loss and claims procedures with adequate services and assistance for all interests in the preparation and submission of losses and claims for adjustment and their collection, including the maintenance of all required files.
   i) Monitor the project and provide advice to the owner and other interests on ways to reduce hazards including advice and consultation on preconstruction surveys of existing properties.
   j) Establish a periodic risk management review and recommendations procedure report.
   k) Evaluate all property and casualty experience; formulate and review all policies, procedures and practices; analyze all forms of insurance contracts including surety agreements and forms.
   l) Develop and implement specific programs to provide adequate surety bonding and insurance for such contractors or other interests, including suppliers, who encounter difficulty in procuring the required protection.
   m) The proposal should contain a recommendation for a coordinated safety program and, as considered necessary, industrial hygiene, rehabilitation, and medical services for the owner and all contractors and the manner in which these should be administered if recommended.

7. Alternate proposals should be submitted for a coordinated insurance program which includes and excludes workmen's compensation pending decision of the owner whether to include such insurance in its coordinated insurance program.

To assist the owner in reaching a decision regarding the selection of an insurance administrator and the adoption of a coordinated insurance program, all proposals should provide answers to the following questions in addition to the respondent's concept for administering an insurance program.

I. General Information

1. Name of firm(s) and date business established.
2. Home office address.
3. Name and address of local office(s), if any.
   a) Name and title of office, partner, etc., in charge of office(s) in local area including phone number;
   b) Date office(s) established in local area or if joint venture, the date of its establishment.
4. Indicate if firm(s), offices, partners, or individuals are duly licensed and authorized for the following major lines:
   a) Property insurance
   b) Casualty insurance
   c) Surety insurance
   d) Boiler and machinery insurance
   e) Excess lines
   f) Surplus lines
   g) Marine

   With respect to each jurisdiction indicate whether licensee are agents, brokers, nonresident brokers, company solicitors, or company employees authorized to solicity, bind and sign.
5. If licensed to handle excess an surplus lines indicate whether firm(s) have binding underwriting contracts with nonadmitted insurers either on a direct or reinsurance basis in any of the foregoing jurisdictions. If so, explain.
   a) What insurance market is proposed to be utilized?
   b) If licensed for excess and surplus line insurance placements, any placements will be with insurers. Describe exceptions, if any.
   c) If firm(s) have or plan the utilization of alien facilities or offices, please furnish preliminary information on possible usage.

II. Property and Casualty Insurance Program Information

1. If your firm is selected for the insurance program, describe how the following responsibilities would be covered:
   a) Architectural and engineering design and property acquisition phases;
   b) Construction phases;
   c) Operational phases.
2. What is recommended design and plan of insurance coverages and their placement. List the advantages and disadvantages of the plan(s) recommended over other plans; premium savings (expressed in percentages or dollars) for each of the plans over conventional-purchased insurance or other plans. Also list estimated additional cost, if any.

3. Based on the plans recommended, indicate proposed organization for each plan.
   a) Show organizational chart and prime functions of each position.
   b) If available, furnish the names, professional qualifications and pertinent background experience of "key" organizational personnel.
4. Based on the program submitted, indicate the insurance underwriting facilities proposed to be utilized. Indicate current knowledge and experience with these facilities.

III. Miscellaneous Information

1. List representative major construction projects in the United States in which firm(s) have been instrumental, including name, date, type, place and coverage:
   a) Public works,
   b) Commercial works,
   c) Industrial works.
2. What overall insurance plan was used by firm(s) in the foregoing projects and the prime underwriters or insurers?
3. Does firm currently handle any major public insurance programs? If so, please furnish names and any data not of previleged nature that would be relevant to the owner for its evaluation of your firm(s). Are clients available as references for your firm, if so, advise how to contact them on a direct basis.

IV. Insurers

The name or names of existing or potential insurers need not be included in proposal.
Those interested in submitting proposals on the basis outlined herein should submit same to: (give name and address).

7. Construction Services

The major expenditure in virtually every urban construction program will be for construction services; therefore, the importance of the procurement function in this area should not be under-rated. An owner should remember that although there are usually a number of competent contractors interested in most construction contracts, there probably will be more and better competition if a good procurement program follows good design and planning activities.

A good procurement program begins with selection of the proper type of contract method, followed by the development of efficient procurement packages. Those packages should be sized by work volume and dollar amount to have greater appeal to the available and competitive contracting firms normally interested in that class and character of work. Good honest marketing with good management usually returns benefits even in urban construction programs.

Types of contracts and the merits and requirements of various methods are described in section G.1; work packaging is discussed in section G.2. The following discussion relates to other items to be considered by an owner when planning and implementing good procurement activities for construction services.

Procurement planning should be coordinated with both scheduling activities and the development of packages so that procurement

schedules are properly sized; timed for worthy competition; and adequately spaced for efficient bid preparation, submittal, and evaluation. The procurement schedule naturally must be coordinated with the availability of funds for contract award and progress payments as well as properly related to the management growth requirements for both owner and contractor forces.

For bids on large projects, most construction agencies advertise complete bid packages to be available to contractors and suppliers between six weeks to two months before the date set for bids to be received. In addition, large projects in the same program usually are scheduled for bidding a minimum of three to four weeks apart. Lack of regard for these time allowances could result in fewer bids or less competitive proposal pricing depending on the job size or contractor risk in the project.

Coverage of risks to be considered in the overall project is provided in section E of this document. The following discussion refers only to the risks that the execution contractor must consider when preparing his cost proposal.

Risk is perhaps the key item in any contracting business, particularly in construction. Contractors are accustomed to assuming risk and are proficient in the evaluation of many types of risk related to construction activities. However, many construction-related risks cannot be suitably measured or adequate costs estimated for assumption of those risks. Some owners make every effort to load every risk on the contractor whether or not that risk can be recognized and evaluated from the data available at bid time. Every owner should consider carefully the magnitude and extent of the risk that he requires the contractor to assume, directly or indirectly.

In general, the greater the number and extent of risks the contractor is required to assume, the larger will be the contingency factors added to his bid. If the risks do not actually occur, the contractor receives a windfall and the owner pays for something he does not receive. When the owner has a relatively large, ongoing construction program, he should consider assuming or sharing risks as a means of lowering overall project costs. Factors the owner should consider in allocating risks are the ability of the party to assume the risk; the degree of control the party may have over occurrence of the risk; the extent to which the grantee needs to fix construction cost in advance of contract performance; the size of the contract; the duration of the contract; and the ability of the party to minimize or mitigate the effect of a risk upon its occurrence. The following risks are typical of those that should be considered:

- Construction-related Risks--Availability of labor, materials, and equipment; late completion; defective design; delayed site

access or right-of-way; actual quantities of work; and changes in the work.

- Physical Risks--Subsurface conditions (geology and groundwater) and natural disasters or acts of God (e.g., flood, earthquake, fire, disease).
- Contractual and Legal Risks--Indemnification and hold harmless; failure of precondition to payment (e.g., bank loan, government financing, appropriation of funds); delayed dispute resolution; owner-contractor-subcontractor-supplier failure; delayed payment on contract and extras; and change order negotiations.
- Performance Risks--Productivity of labor; productivity of equipment; suitability, availability, and accessibility of materials; mistakes or defective work; accidents; labor disputes; contractor competence (judgment, planning, and management); and conduct hindering performance of the work.
- Economic Risks--Inflation (e.g., cost of money--labor, material, and equipment cost escalation); cost of labor, material, and equipment; labor contracts; and national and international impacts (e.g., OPEC, coal strike, devaluation).
- Political and Public Risks--Environmental; traffic maintenance; public disorder; government acts and regulations (e.g., OSHA, MBE, EEO); permits and ordinances; and tax rate changes.

Each of these risks can be entirely allocated to one party or the other or can be shared by the parties in some fixed proportion. For example, escalation can be shared 70 percent by the owner and 30 percent by the contractor. This would relieve the contractor of a substantial cost impact while providing a strong incentive for timely performance. Risk allocation and sharing must be implemented by appropriate contract language, and a conscious decision should be made with respect to the allocation or sharing of each risk listed above.

Risk also can be transferred to third parties. The following means are available to transfer various risks:

- Bonding--A surety company can assume the risk of contractor default in preformance and failure to pay subcontractors, laborers, and vendors. In addition, the requirement for a contractor to furnish a surety bond can serve as a means of prequalification.
- Insurance--This is the normal means of transferring catastrophic risks.
- Indemnification and Hold Harmless--One party can contractually assume the risk of loss through the fault of another. This is often criticized as requiring duplicative insurance coverage and as a disincentive to proper precautions for care and safety by the indemnified party.

Selection of construction contractors should be based on the qualifications of the contractors. The following general qualifications should be considered:

- Reputation and standing of the firm and its principal members
- Experience and technical competence of the firm in performing comparable work
- Past record in performing work for government agencies and private industry, including performance from the standpoint of cost and the nature, extent, and effectiveness of contractor's cost reduction program, quality of work, and ability to meet schedules (where applicable)
- Volume of work in previous years and current workload
- Interest of company management in the project and the expected participation and contribution of top officials
- Experience in purchasing materials and equipment, including special equipment
- Ability to furnish or to obtain adequate construction plant and equipment
- Record in labor relations, particularly effectiveness in preventing work stoppages, and the possible effect of its labor policies and practices on other contractors at the site
- Safety record
- Adequacy of accounting system
- Geographic location of home office and familiarity with the locality in which the project is located.

Personal and organization considerations include:

- Specific experience and qualifications of key personnel proposed for assignment to the project including technical skills and abilities in planning, organizing, executing and controlling; abilities in overall project coordination and management; and experience as a team
- Proposed project organization, delegations of responsibility, and assignments of authority
- Availability of additional competent, regular employees to support the project and the depth and size of the organization (so that any necessary expansion or acceleration of the project could be handled adequately)
- Experience and qualifications of proposed consultants and subcontractors
- Ability and willingness to perform work, as required, with in-house forces or on a subcontract basis
- Ability to assign an adequate number of qualified key personnel from its own organization, including a competent supervising representative.

8. Inspection Services

Inspection is the act of ascertaining that the product purchased by the owner consists of the materials intended to be purchased and

placed or located so as to function in the desired manner in the finished product or system. The physical act of inspecting can take many forms and the responsibilities associated therewith can be discharged by various types of performance or assignment.

Properly performed inspection services serve a number of purposes. The intent of plans and specifications may not always be clear to the craftsmen or workers charged with developing the finished product from raw or component materials. It is human nature to perform with varying levels of attentiveness from time to time or an outside source may be cause for distraction and consequent erratic performance by a worker. An inspector, with appropriate training and experience, charged to perform in the interest of the owner will provide an independent interpretation as to whether the placement or utilization of a material or component has been properly accomplished. It will always be in the best interest of all to have an activity properly completed on the first attempt. Diligent and cooperative efforts on the part of the inspector can do much to ensure timely, proper, and economical production. Depending on the character of the activity or end product, judgments must be made concerning the point at which detailed inspection services are required. All factors considered, there comes a point at which a manufacturer's warranties concerning composition and performance must and can suffice.

There are two principal methods of discharging inspection responsibility. Most commonly, relatively detailed independent inspection services are performed by staff or agents of the owner. However, the contractor or supplier can be charged with all inspection services associated with quality control and performance of a purchased end product.

When a public entity is the owner, it is a guardian for the end user, the relevant body of taxpayers and affected citizens. To discharge this responsibility with reasonable assurance that independent judgments and integrity have been exercised in the performance of inspection services requires a major policy decision. It is recommended that inspection services on urban construction programs under the auspices of public entities be accomplished by staff or retained consultants who are responsible only to the "owning" agency.

9. Utility Services

There are two facets to the owner's relationship with utility organizations--he is a user of utility services (e.g., electric, gas, water, sewage disposal) and he is a user of "common corridor" or other real estate easement space where the project will be built. As a user of services, procurement negotiation will require consideration of such factors as rates, supply and demand, peak loads, energy efficiency and conservation, points and conditions

of service, ownership of facilities, and responsibility for operation and maintenance. As a user of common corridor and easement space requiring relocation or special protective treatment of existing facilities, agreement must be reached on assignment of responsibility for work to be performed by the owner's consultants and contractors and by the utility organizations. Problems frequently are encountered in assigning costs attributable to the betterment of existing utility facilities (adjusted for current worth and salvage value) and to relocation or protective work to be performed.

At the earliest opportunity, master agreements with the utility organizations concerning the costs of taking necessary actions and the assignment of tasks, financial responsibility, and schedule control must be negotiated with utility organizations to avoid delays and disputes. Publicly owned and privately owned utilities may have to be treated differently regarding costs to be borne for necessary relocations since local ordinances and agreements may exempt public utilities, (and, in some cases, private utilities) from being required to bear such costs.

10. Data Processing Services

The primary function of data processing services is to allow management to control, organize, and manage information on the status or history of various projects. This type of information management may or may not involve the use of a computer. When no computer is used, there are certain limitations on the overall size of the manual effort, and these are dictated by staff size. When a computer is deemed necessary, it is essential to have a senior staff member with considerable computer experience. The primary applications for data processing are project size forecasting, project progress analysis, and project quality control and budgetary monitoring.

The alternatives available include:

- Operating an in-house data center with necessary supporting staff and equipment
- Contracting with a consultant to manage all data processing services on-site (facilities management) or off-site (service bureau)
- Requiring contractors to perform their own data processing using rigid and frequently audited procedures.

Data processing services may be required to support the following:

- Management of the contractor's bid, data, etc., along with bid tabulation efforts
- Construction estimation efforts
- Fund allocation and expenditures by project

- Project deadline control (PERT or PERT/COST techniques)
- Contract information (detail and summary; time and cost)
- ICES/STRUDL (Civil Engineering packages developed by MIT)
- COGO (Co-ordinate geometry, surveying aids)
- Payroll, general ledger, accounts receivable, payable, and other financial systems
- Manpower and labor costs analysis
- Contract modification control
- Spare parts or engineering accounting
- Energy or utilities management
- Modeling and/or simulation of design or environmental factors
- Word processing capabilities (for bid preparation, etc.).

11. Materials and Equipment

Permanent materials include working materials (e.g., concrete, lumber, steel) and structural units associated with running tunnel, stations, track, bridges, and elevated rail. The procurement of permanent materials is associated with two broad phases of the work--construction and maintenance.

During construction, most permanent materials are provided by the contractors under the terms of contract. However, in some circumstances, it may be advantageous for the owner to provide materials. Materials supplied by the owner may include those used on a recurrent basis throughout the system and those requiring a long lead time for delivery. The decision to use owner-supplied materials should be based on judgments regarding savings associated with direct, early procurement as opposed to both the costs of stockpiling and the risks stemming from the owner's participation in the delivery and fabrication process. The choice of areas for stockpiling must be made on the basis of available property and suitable location with respect to the sites of both construction and manufacturer delivery.

For a transit project, owner-supplied materials may include but are not limited to:

- Rails (including tangent rail used on relatively straight sections of the line and heat-treated rail used at curves and switch-points)
- Ties (including both wood and concrete ties)
- Ballast
- Structural members (including units that have a wide application over several sections of the system such as girders for elevated rail).

System facilities will require maintenance and upgrading for which permanent materials must be provided. The nature and amount of the required materials will depend on the characteristics of the given system (e.g., number and size of stations, total mileage, portion

of system underground, portion of system above ground), types of construction materials incorporated in the system, and the lengths of time portions of the system are in use. Warehouse and stockpile locations must be chosen so they are accessible to all parts of the system and close to sites of manufacturer delivery.

Materials that have a systemwide application generally are procured by blanket-order on the basis of estimated annual or biannual need. The orders generally are let on a competitive bid basis, with materials delivered as required throughout the term of contract. The items procured in this manner might include rails; ties; ballast; and materials to effect minor structural, architectural, and mechanical repairs. This latter category of materials can be classified according to the building trades with which they are associated (e.g., carpenters would require lumber, sheeting, and barricades and masons would require concrete blocks, cement, and tiles).

Structural units (e.g., girders, columns, tunnel linings) generally are procured as they are needed in the course of system repair for damages and deterioration.

Construction equipment normally will be provided by the construction contractor. Owner-furnished equipment should be considered when mobilization and demobilization of equipment by each contractor will add to the cost unreasonably, the equipment will be needed during the operational phase, or control of the equipment will add to quality control or standardization programs. When providing equipment, responsibility for maintenance and loss or damage must be clearly delineated.

The owner should consider furnishing those elements of the system that must be standardized. When furnishing system elements, the owner should assume responsibility for timely delivery and quality and accuracy of shop and installation drawings and instructions.

H. DESIGN PROGRAM

1. Preliminary Design

During the conceptual planning phase of a project, which includes conceptual engineering, design related work should be performed by professional planners, engineers, and architects who are experienced in the development and execution of construction programs. If general project criteria, specifications, and drawings are not completed in the conceptual planning phase, they must be completed in the preliminary design phase to guide final design. To further the design, the following should be done:

- Additional data collection, topographic surveys, and geological and geotechnical investigations of critical areas should be accomplished.
- Real estate descriptions should be prepared and acquisition procedures started.
- Specifications should be prepared for the procurement of permanent equipment with a long lead time before delivery.
- Design and construction packages should be identified.
- Master agreements should be made with involved organizations, utilities, and regulatory agencies with provisions for the accommodation of general conditions that may develop during the design and construction phases.
- The program of public information, participation, and support begun during conceptual planning should be continued.

Throughout the design phase, consistency must be maintained with the environmental impact statement previously developed. Refined environmental assessments should be performed; if not previously completed, the final environmental impact statement should be processed.

2. Final Design

The purpose of the final design stage is to prepare the final drawings, technical specifications, and contract documents required to obtain new construction contract bids. Therefore, it is important that construction concerns are dealt with adequately in the design phase. The quality of drawings, specifications, and contract terms has a pervasive influence on the contract bids. The owner will place prospective construction contractors in the best position to submit realistic bids if he: provides a clear and specific assignment of risks; discloses all engineering and geotechnical information gathered; provides for contract adjustments for differing site conditions; identifies clearly the contract obligations of both the owner and contractors; and defines clearly the avenues for contract adjustment for delays resulting from action, lack of action, or delayed action. Normally, the design phase includes preparation of the engineers' estimate and schedule, analysis of construction bids, and contract award or recommendation for award. (For additional information relating to the design program, see also sections C.1.a, C.1.b and C.4.)

3. Design Services During Construction

The construction phase starts with the awarding of construction contracts. For multiple contract projects, bidding should be scheduled in accordance with the contract strategy and should be timed so that long-term contracts can begin. Offerings should be spaced in a manner that provides prospective contractors with enough time to bid on successive contracts. Whenever possible, and particularly for underground construction projects, the sequence

of offerings should be timed to avoid dates that are close to bid dates of contracts for other major projects in the country. Contract sequencing is also important to avoid competition among contractors for construction materials and for the work force, especially in regions where there is a limited, experienced labor pool.

Close working relationships with other agencies involved--e.g., railroads, utilities, and regulatory and funding agencies--should be maintained. Activity should be continued on political liaison and public information and support programs.

I. REAL ESTATE ACQUISITION AND DISPOSAL PROGRAM

Because every construction program requires interests in real estate, it is essential that the necessary interests be acquired in a timely, orderly, and legal manner and in a sequence that will prevent potentially costly delays. A comprehensive real estate program (particularly for federally assisted construction projects subject to the legal requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970) normally will include in its organization and management scheme the planning elements discussed below.

Close coordination of real estate matters among the project planners, programmers, designers, engineers, construction managers, and the real estate organization is not only desirable but mandatory if efficiency and economy in the construction and operation of the project are to be achieved. Such coordination should stimulate the development by each element of the team of general knowledge concerning the nature and scope of the other team member's functions and interfaces and should facilitate the development of a real estate schedule that reflects the estimated time of the sequential steps to be taken by the real estate organization throughout the acquisition, relocation, and demolition process.

Such a schedule can be integrated in the construction schedule and adjusted to meet program changes or as warranted by changed circumstances. For example, when efforts to acquire a real estate interest by negotiated purchase and voluntary agreement reaches an impasse necessitating the use of eminent domain (condemnation) procedures, the resulting delays, if not anticipated as a possibility in scheduling, could result in costly construction contract delays. Also, in the area of relocation assistance, the law requires that all persons to be displaced by the project be relocated adequately in decent, safe, and sanitary housing comparable to or better than the housing they are leaving. Failure to make advance studies of available family housing resources in the vicinity of a proposed project could delay start of a project.

State and federal agencies having substantial experience in implementing the real estate procedures required by the Uniform Relocation Act include state highway administrations, the Federal Highway

Administration, the U.S. Department of Transportation, the U.S. Army Corps of Engineers, the U.S. Department of Housing and Urban Development, the U.S. Department of Interior, and the General Services Administration. The following requirements are typical of regulations used to implement a real estate program for an urban transit project:

- Identification/Certification of Real Estate Required--Rights of way (permanent/temporary), easements (permanent/temporary), and lesser interests (permanent/temporary)
- Appraisal Plan--Staff and/or contract review and support of litigation (condemnation actions)
- Acquisition Plan--Direct purchase and acquisition by eminent domain (staff/counsel/outside)
- Property Management Plan--Interim use/maintenance prior to project construction and management of excess property prior to disposal
- Relocation Assistance Plan--Availability studies, notification of eligibility of occupants of dwellings, business, and farms, relocating occupants/furnishing advisory services, and claims processing
- Demolition Plan--Procurement and administration of demolition contracts and use or sale of improvements/salvable materials
- Disposal Plan--Screening and disposal by sale, exchange, lease, easement, joint venture development
- Scheduling and Funding Plan--Schedule of real estate activities to meet project requirements, budgeting, administration, and accounting.

J. COMMUNICATIONS PROGRAM

Consistent communication with the entire community and with specific audiences is essential to impart, in varying degrees of detail, information concerning system cost and timing and the physical status of the developing project. With proper attention to communication, a public works program can maintain project supporters and remove elements of doubt and rumor that are utilized by project detractors and critics.

1. Audience

The first requirement is to identify the appropriate individual audiences. These may include:

- The governing body (board, commission or district)
- Local governments (city and county levels)
- State government (departments, agencies, and general assembly, if appropriate)
- Federal government agencies (Departments of Transportation, Interior, Defense, etc.; General Services Administration; and Congress, if appropriate)

- The public sector (civic associations, citizen groups, religious groups, and business associations)
- Internal staff (management, supervisory, and employee groups)
- The media (press, radio, and TV).

2. Responsibility for Reporting

The credibility of a construction project depends upon quick, responsive, and consistent information being accurately conveyed to all audiences. Regardless of the size of a project, a spokesman should be identified clearly. It is essential to establish the source of information concerning project performance, schedule, and cost; this source should be centered in an individual or office that generally is designated as "program control." An information officer should be appointed to act as a clearinghouse for the flow of information to and from the public and the media. If a multitude of government agencies and government levels are involved, a government liaison or office should be established.

3. Reporting Systems

The owner should require that each of the principal project tasks be reported on at the frequency and in the format necessary to provide essential information for monitoring the construction project. The owner also has an obligation to prepare reports on the project's financial status and to provide such reports to the government agencies (i.e., state or federal) that provided public funds for the construction program.

The types of reporting that should be required are:

- Administrative reports--general administrative, personnel, data processing, and purchasing
- Financial reports
- Design and construction--architecture, engineering, equipment design, real estate acquisition, construction, and startup program.

K. CONSTRUCTION PROGRAM

During the design phase and again in the prebidding period, experienced construction personnel should prepare a work plan with cost estimates tied to related schedules for the work and quality envisioned. Specifications also should be prepared and reviewed during the design phase to ensure that the cost estimates, schedule, and quality are related, compatible, and acceptable to the owner or financier. This emphasis on early cost estimates with well-defined parameters will help to preclude surprises at a later date when commitments have diminished flexibility for correction. In addition, a good construction estimate and related schedule is essential input for schedule and cost items in management control systems. Further, the cost estimate serves as the proper basis for

manpower requirements that must be considered by the owner and community when weighing the effects or demands of project execution.

The owner should remember that in every project there are three essential elements--quality, cost, and schedule. All are variables, and if one element is altered or changed, the other elements are affected, usually with detriment to the contractor and the owner. Any problem that could cause trouble with respect to any of the essential elements in execution should be ironed out before contract bid and award.

Good specifications are as essential as good plans. An owner cannot assume that a specific event will occur just because it seems logical. Environment, circumstances, and situations can change; therefore, the bid documents should state any mandatory or essential requirements in clear terms.

These general statements apply to all projects, but to ensure a successful project, an owner must make every effort to spell out his specific needs, and how he expects to do business with the contractor. Contract and contract document difficulties are far fewer when the requirements and responsibilities of both owner and contractor are clear to each and the owner lives up to the requirements of his own documents.

Continuing on the theme that anything that affects project quality, schedule, or cost is important to both the owner and the contractor, a partial checklist of typical items that can have a bearing on the successful execution of a project is presented below. The owner should ensure that these items are considered for the execution phase of the project.

1. Construction Operations

- Sequence of work, order of work, completion priorities
- Adequate right-of-way available to contractor
- Construction area access and storage area
- Construction area prefabrication needs
- Utility interference, relocation
- Utility service available to contractor (including water from city hydrants, etc.)
- Limitation or restraint on work period, such as night hours or weekend work prohibition
- Explosives limitations, regulations on use
- Traffic handling plans, lanes, directions, hours, lighting, barricades, etc.
- Licenses and permits available, requirements, jurisdiction (if lead time is required, owner should obtain permits, etc.)
- Dewatering needs, regulations, problems, recharge requirements
- Buildings and adjacent structures, settlement, underpinning, preconstruction photos, records

- Field surveys, elevation and settlement monitor
- Borrow pits, select material sources, quarry sites, gravel pits
- Disposal, waste sites
- Railroad crossings, maintenance, flagmen, insurance
- Assigned subcontractors
- Concurrent contracts and contractors on site
- Escalation, partial payment.

2. Contract Administration

- Bid quantities accurate, not overstated
- Bid packages prepared, reviewed, compatible
- Contract period dates for bid, award, notice to proceed, milestones, completion, working days with definitions
- Milestone dates, startup restraints (e.g., completion of work in one area before work is allowed in another area), completion priorities
- Payment provisions, progress payments, retainage
- Funding limitations
- Mobilization item
- Payment for materials and equipment on site
- Subcontracting limits, general contractor requirements, bidder qualification, bonding requirements, insurance requirements
- Inspection, quality control
- Approvals, submittals, shop drawings, requirements and time limits for action and return from agency
- Safety, regulation reference, control
- Weather, time extension
- Change orders, recognition, submittals, action, execution, time extension, negotiation, payment
- Extra work, force account
- Project administration, contracting officer, etc., and definition of responsibilities and duties
- EEO, minority subcontractors, government program requirements, etc.
- Disputes, change orders, claims
- Owner caused delay, time extension, payment
- Acceptance of work, partial acceptance, beneficial occupancy
- Value engineering program
- Progress records, photographs.

3. Materials/Logistics

- Materials, available, not sole source
- Construction system--sole source or high royalty systems not required or necessary
- Geologic investigation, logs, samples available for inspection, groundwater study
- Owner-furnished equipment and materials
- Equipment and supplies with long lead time problems, recognition
- Material tests and samples from project sources for borrow, select material, gravel, rock, rip-rap, etc.

4. Manpower

The most important element in the construction execution process is manpower, whether it be craft, professional or unskilled. In enormous undertakings, the demand for specific craft skills may tax even the largest communities. The project work plan should be analyzed and reviewed to ensure that there is no inordinate need for any particular skill or craft if it can be avoided without adverse impact to the project. In determining costs for a given project, contractors will analyze manpower demand and eliminate peaks and valleys in demand by adjusting, usually extending, the schedule. The action is termed "manpower leveling." For example, reinforcing steel, concrete formwork and electrical work should be evaluated for manpower leveling needs and rescheduled accordingly (see also section D).

L. LEGAL REQUIREMENTS

The mechanics and channels of communication for fulfilling all applicable legal requirements should be enumerated as follows:

- Permits--Name and address of each agency, liaison, who must file, time required for issuance
- Approvals--Name and address of each authority, liaison, nature of approval required, details of communication and coordination
- Dispute Resolution--Procedures for resolution and identification of responsibility and authority at all levels of management (see also, section F, Dispute Resolution).

M. SAFETY PROGRAM

The prevention of accidents during execution of a construction project should be a primary concern of all participants and the responsibility of all levels of management and supervision. Accidents cause suffering and hardship to those immediately involved and result in project delay and additional expense to owners and contractors. A low accident rate is a direct result of a carefully planned safety program that is conscientiously carried out by management and supervision. Overall responsibility for assuring the development and implementation of a safety program rests with the owner's project management, and the discussion below is offered as general guidance.

1. Basic Assumptions

The safety program for managing any urban construction project should be formulated on the following basic assumptions:

- Management and supervision are charged with the responsibility of preventing the occurrence of incidents or conditions that could lead to occupational injuries or illnesses.

- Safety should never be sacrificed for production and should be considered to be an integral part of risk management, quality control, cost reduction, and job efficiency.
- A good safety record reflects the quality of management, supervision, and the work force.
- The established policy should be to accomplish the work in the safest possible manner consistent with good work practices. Management at every level should be charged with the task of translating this policy into positive actions.

2. General Provisions

The following general provisions should apply:

- The safety program should outline management safety policies and procedures and be in compliance with and be supplemented by all applicable federal, state, and local safety and health regulations and standards (including those issued under the Occupational Safety and Health Act of 1970).
- Specific contract and owner requirements should be stated.
- In case of a conflict between standards or regulations, the stricter requirement should apply.

3. Organization

The owner's project manager should have full responsibility for executing and implementing a program of employee protection and accident prevention on the project. A responsible safety manager should be designated to administer and supervise the overall project safety program.

a. Safety Manager

The designated safety manager should have the authority and ability to enforce established safety requirements and should report directly to the project manager. In carrying out the assigned function, the safety manager should be assured that the following are performed:

- Acceptable policies, practices, and standards to promote the established safety program and administer assigned functions to aid in this overall responsibility are applied.
- The medical and first aid service and program are administered and coordinated.
- Accepted safety and health standards and code regulations are applied to the work under way as it applies to personnel, structural, and equipment operating standards.
- The execution of required environmental tests are conducted and supervised in order to eliminate or control hazards that could contribute to or result in an occupational illness.
- Established standards and regulations to maintain an effective pollution control program are applied.

- Injuries, conditions, and incidents that do or could involve actual or potential liability are investigated.
- Adequate records or pertinent data are maintained and the required reports on individual job occupational injury and illness experience are compiled.
- Equipment, structures, and work in progress are inspected to determine that supervisory follow-ups are given to ensure that regulatory safety and health standards and all applicable codes are followed.
- A project security program is administered and coordinated.
- Promotion material to further safety and health education among job craft and supervisory personnel are planned and utilized and safety classes and/or first aid instructions for supervisory and craft personnel are conducted.

b. Project Contractors

The manager of each contractor should have full responsibility for executing and implementing a program of employee protection and accident prevention which is consistent with the requirements of the overall project safety program.

4. Overall Project Safety Program

a. Initial Priorities

The initial priorities of a project safety program are as follows:

- As required by contract stipulations, inherent job hazards, recommended industry practices or by other factors, the appropriate managing authority should hire and assign safety, medical, and/or security personnel to the project.
- First aid and medical facilities or arrangements with existing medical establishments should be established and emergency procedures, including adequate communications and emergency transportation, should be developed and implemented.
- Adequate fire protection and security programs should be established and maintained as required.
- A job safety hazard analysis should be made to identify inherent and potential hazardous conditions and steps should be taken to eliminate or prevent these hazards; hazards that cannot be eliminated should be controlled and properly marked with warnings that specifically explain the dangers to all new employees.
- Specific safety and health work procedures reflecting the job hazard analysis should be developed to ensure safe work conditions.
- Liaison should be established between representatives of the owner, the insurance carrier, and other personnel to identify and coordinate such items as measures needed to protect the public; local, state, federal, and owner regulations applicable to the project; procedures for reporting accidents and property

damage; emergency procedures for seriously injured or ill persons; and applicable special conditions or requirements.

- The project or safety manager should establish procedures for maintaining adequate records concering personal injuries and record of treatment; accident investigations; reports to compensation carriers, reports to the owner; disabling (lost time) accidents and injuries; property damage; daily testing logs concerning dust, gas, and explosive work or possible property damage; specific summary reports required by the owner; and records and reports required by state and federal agencies.

b. Safety Inspection and Loss Control

The safety manager or other competent safety personnel and project supervisors should conduct daily inspections of work operations, equipment, storage areas, and facilities. Unsafe acts or unhealthy conditions should be noted and pointed out to the supervisor in charge. Serious or repetitive violations should be documented and transmitted to the contractor representative for corrective action.

When a condition or practice exists that could reasonably be expected to cause death, serious physical harm or extensive damage to property, it should be the policy of the project manager to cease operation on the portion of the work affected until the hazardous conditions are corrected. Carelessness or disregard for accepted and mandatory safety and health standards should not be tolerated. Contractors should be expected to discipline or terminate employees who violate established rules and regulations.

Each individual contractor should be held responsible for his own safety program. However, the project manager should provide overall safety surveillance to ensure compliance with established safety and health policies and procedures.

5. Specific Safety and Health Requirements

A list of those procedures, rules, and other mandatory regulations that are required by the locale, type of work, or the client's or other regulatory authority's codes, standards and specifications should be prepared. The following should be included:

- Specific responsibilities
- Reporting and recordkeeping requirements
- Special safety and health rules and codes
- Safety and medical department and facility requirements
- Safety orientation and training
- Enforcement procedures
- Security program
- Fire protection and prevention plan.

N. OPERATIONS AND MAINTENANCE INTERFACE

The continuing mission of the owner generally will be to operate the system after the construction project is completed. Accordingly, proper attention must be devoted to preparation for startup throughout the planning, engineering, and construction phases of the project. Key operations and maintenance positions must be identified during the planning phase, and qualified personnel must be selected for these positions and brought on early to ensure that their expertise is used in planning and designing the project.

The owner and the other members of the project management team must develop and document operations and maintenance plans and procedures during the early part of the design phase. A complete family of test procedures, operating manuals, as-built drawings, and performance documents should be available prior to final testing and acceptance.

Adequate time must be scheduled for a thorough program of testing, startup, and running of the system prior to the scheduled initial operation. Key operations and maintenance personnel should participate fully and responsibly in the testing program to prepare for early and efficient system operation and to train and develop experienced personnel for operations and maintenance.

O. COMMUNICATION INTERFACE MANAGEMENT

The major interfaces at which performance failure could result in serious disruption of project continuity or efficiency or could prevent timely completion of the project should be addressed. These interfaces exist between the companies involved as partners and under contracts, between functional units, between project locations, between project phases, between project and governmental regulatory agencies, and between private and other public interests.

To enhance interface management, the following should be defined clearly: (1) responsibility, authority, and accountability at the interfaces between various project functions; (2) inputs and outputs in terms of content and schedule; and (3) lines and procedures for communication. Procedures for communication within the project organization should include authorizations, reports, meetings, and reviews supported by records management. Procedures for communication with elements external to the project should include public relations; applications for permits and licenses; and reporting requirements imposed by contracts, grants, regulations, and other legal requirements.

P. MAINTENANCE OF THE PLAN

Responsibility should be assigned to ensure that the portions of the management plan incomplete at the time the original plan is issued are completed and that revisions required by changes are made. Periodic reviews of the plan should be made to ensure its currency and appropriateness.

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